DEPARTMENT OF MINES AND AGRICULTURE, SYDNEY.

RECORDS

OF THE

GEOLOGICAL SURVEY OF NEW SOUTH WALES.

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CORRIGENDA.

Page 35, line 22. For *Mr. J. C. H. Mingaye, F.C.S.*, read *Mr. H. P. White, F.C.S.*
Page 90, line 14. For *X* read *IX*.
Page 93, line 30. For *Maitland (D. G.)* read *Maitland (A. G.)*.
Page 167, line 30. For *bead* read *beak*.
Page 181, line 3. For *Permo-carboniferous* read *Permo-Carboniferous*.

DEPARTMENT OF MINES AND AGRICULTURE, SYDNEY.

RECORDS

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GEOLOGICAL SURVEY OF NEW SOUTH WALES.

Vol. V.] 1896. [Part 1.

I.—The Occurrence of Artesian Water in Rocks other than Cretaceous:* by E. F. PITTMAN, A.R.S.M., Government Geologist.

IN September last I reported the discovery of palæontological evidence proving that artesian water occurs in New South Wales in rocks of greater age than the Lower Cretaceous sediments to which it had hitherto been supposed to be confined, and the object of the present paper is to give a brief account of the facts referred to, together with some additional evidence gathered during a recent trip through parts of Queensland and New South Wales.

The railway now in course of construction between Narrabri and Moree passes over black soil plains, on which there is no permanent water supply which could be utilised for the locomotives, and it was an inquiry by the Railway Commissioners as to whether there were any prospects of obtaining artesian water at Woolabrar, on Dobikin Run, about midway between Narrabri and Moree, which led to my making an examination of this country.

The rocks penetrated by wells on the Dobikin Run were found to consist of white and grayish sandstones, bluish-gray sandy shales, brownish clays, and nodules of clay ironstone. A characteristic feature of these sediments was that they crumbled or became disintegrated freely on exposure to the atmosphere, owing, no doubt, to the quantity of water contained in them. In these rocks were found numerous plant impressions, among which *Tæniopteris Daintreei* (McCoy), a fossil plant characteristic of the Mesozoic Coal-Measures of Victoria, the Clarence River

* Paper read before the Royal Society of New South Wales, 4th December, 1895.

Series of New South Wales, and the Ipswich Coal-Measures of Queensland, was readily recognisable. Another plant from this locality was identified by Mr. W. S. Dun, Assistant Palæontologist to the Geological Survey, as belonging to the genus *Baiera*.

Similar rocks were observed on the Terry-Hie-Hie Run, about twenty-five miles to the north-east; and still further north at an old shaft known as Moloney's Well, fourteen miles east of Moree, *Tæniopteris Daintreei* was again obtained. On arriving at Moree an examination of the drillings showed that, in their lithological characters, the rocks penetrated by the bore very strongly resembled those met with at Dobikin and Terry-Hie-Hie, and a subsequent examination of the contents of the core-box, in Sydney, enabled me to detect *Tæniopteris Daintreei* in one of the few solid pieces of rock which had been obtained by reaming; the greater part of the drillings having been extracted in a fine state of division, owing to the percussive action of the Canadian Drill.

The evidence thus obtained proves beyond doubt that the Moree Bore, which yields about three million gallons per day of artesian water of very good quality, is not in the Lower Cretaceous rocks, as was previously supposed, but in rocks of the same age as the Ipswich Beds of Queensland, the Coal-Measures of Victoria and the Clarence River Coal-Measures of New South Wales.

In subsequently examining the core-box from the Coonamble bore, I identified, in a solid piece of "reamings," a specimen of *Tæniopteris Daintreei*, and one of *Thinnfeldia odontopteroides* (Morris), another fossil-plant, characteristic of the Hawkesbury Series, which are regarded as homotaxial with the Clarence Series. The Coonamble Bore yields a supply of about 1,800,000 gallons of artesian water per day.

On January 20, 1894, a paragraph appeared in the *Daily Telegraph*, stating that the Rev. J. M. Curran had furnished a report to the Minister of Works to the effect that in his opinion the rocks pierced by the Coonamble bore were Triassic and not Cretaceous. Inquiries recently made at the Works Department elicited the reply that no such written report had ever been received from Mr. Curran; but I understand that Professor David questioned Mr. Curran at the time as to his reasons for supposing these rocks to be Triassic, and his reply was that although he had no definite palæontological proof of the age of the rocks, his opinion was based upon their lithological resemblance to those of the Dubbo District with which he was familiar, and upon the occurrence of a number of indeterminable plant-remains, similar to those common in the Dubbo beds.

In 1891, Mr. Robert Etheridge, Junr., identified a specimen of *Tæniopteris Daintreei* from the Nyngan Bore, and during the present year Mr. W. S. Dun recognised another specimen of the same fossil plant in some rocks forwarded by Mr. W. L. R. Gipps, from Terabile Creek, four and a half miles from the Castlereagh River.

It is clear therefore that a large portion of the area hitherto regarded as Lower Cretaceous, is in reality occupied by rocks of Triassic or Jurassic age, and it is also proved that these rocks are artesian water-bearing, and that they extend much further to the eastward than the eastern boundary of our artesian basin, as tentatively laid down on the Geological Map of the Colony. It may here be remarked that it is only by information derived from bores and wells, that the age of the underlying formations can be determined in most of the country hitherto referred to, for the reason that it consists of plains, the surface of which is covered by Pleistocene and recent deposits.

I have recently returned from a trip through part of Queensland and that portion of New South Wales lying to the north and north-west of Inverell, the object of my visit being to trace and map the eastern boundary of this newly discovered artesian water-bearing basin. I find that on the Dumaresq River (the northern boundary of the Colony) it passes about fifteen miles to the west of Texas, and I have, so far, traced it in a more or less south-westerly direction to the neighbourhood of Wallangra, the dip of the beds being to the west or south-west. If this boundary be assumed to continue so as to take in the Coonamble and Nyngan bores, it will easily be realised that a very considerable addition must be made to the area of the New South Wales artesian basin as hitherto shown on our Geological Map.

But if the discovery of artesian water in rocks of Triassic or Jurassic age be a matter of importance to New South Wales, it is, I think, of still greater importance to the Colony of Queensland. Mr. R. L. Jack, the Government Geologist of that Colony, and his Assistant, Mr. A. Gibb Maitland, were engaged during the year 1894 in mapping the outcrop of the basal or intake beds of the Lower Cretaceous basin of Queensland. They found these beds to consist of very porous (bibulous) marine sandstone, which Mr. Jack has named the "Blythesdale Braystone," and which he described in detail in an interesting paper read before the Australasian Association for the Advancement of Science at its Brisbane Meeting in January last.* The outcrop of this rock was traced from near Texas to Roma, following a more or less north-westerly course, but overlaid in places by the Desert Sandstone (Upper Cretaceous.)

The most southerly portion of this outcrop is described by Mr. Jack as differing somewhat from the typical Blythesdale Braystone as seen on the Weir River, and at Roma and other places further northward. The rock to the west of Texas is a gritty sandstone, and it contains cementing material, which appears to be absent from the typical Braystone; the latter is also, as a rule, much finer grained.

I have inspected the Braystone beds in the neighbourhood of Roma and Blythesdale, and I have also seen the sandstones fifteen miles west of Texas, and am strongly of opinion that the latter belong to freshwater beds of Triassic or

* See also Artesian Water in the Western Interior of Queensland, Bull. Geol. Survey Q'land, 1895.

Jurassic age—in other words, to the Ipswich Measures, and not to the marine beds of the Lower Cretaceous (Blythesdale Braystones). I have, as already stated, traced these gritty sandstones without any sign of a break in their continuity, from the point fifteen miles west of Texas to Wallangra, and from the spoil heap of a well, ninety feet deep, twelve miles south-west of Yetman, I have obtained impressions of the fossil plant, *Tæniopteris Daintreei.*

In his paper read before the Australasian Association for the Advancement of Science, Mr. Jack describes the Blythesdale Braystones as the intake beds of the Cretaceous basin, but he adds that he strongly suspects they "may be reinforced by the agency of strata geologically on a lower horizon." He goes on to say, "till lately the best information available led me to the belief that the Trias-Jura formation, or Ipswich Coal-Measures, was succeeded conformably by the Lower Cretaceous or Rolling Downs formation, but in the last trip I have seen unmistakable evidence of an unconformability between them. It may be that the bibulous lower members of the Cretaceous rest directly on sandy members of the Ipswich Coal-Measures, which dip in the same direction. In this case the sandstone beds above the Toowoomba basalts, and the Murphy's Creek beds below, would feed the Blythesdale Braystones, and still further tend to equalise the supply by making good the loss entailed by the supposed connection of the latter with the ocean."

Up to the present time, however, no bores in search of artesian water have been put down in the Trias-Jura rocks of the Downs to the north-east of the line of outcrop of the Blythesdale Braystone. Two bores have been put down in the Ipswich Coal-Measures to the east of the Dividing Range, but neither of them was very successful. The site of one of these bores was Eagle Farm, near Brisbane Racecourse, and here an artesian supply of about 8,000 gallons of inferior water per day was obtained. The other bore was at Laidley, fifty-one miles west of Brisbane, and it did not result successfully so far as obtaining an artesian supply. It appears to me, however, that the positions of both these bores were unfavourable. The Coal-Measures at Eagle Farm appear to be, to all intents and purposes, isolated from the main body of the Ipswich Coal-Measures which underlie the Downs; for a large part of the City of Brisbane is built upon hills of palæozoic schists, against which the Coal-Measures thin out, and which act as a barrier between those on the east and those on the west of Brisbane; the Laidley Bore, also, does not appear to be favourably situated, when its altitude and that of the intake beds are taken into consideration.

With the country to the west of Toowoomba, however, the conditions appear to me to be very different.

Murphy's Creek Railway Station, to the east of Toowoomba, is seven hundred and eighty-eight feet above sea-level, and from there up to the top of the Dividing Range, near Toowoomba, are seen, at elevations increasing up to about 2,000

feet, outcrops of sandstones of the Trias-Jura formation, with some supposed interbedded lavas. Some of these sandstones are very porous, and are, therefore, well adapted to act as intake beds for artesian water. Their dip is to the west, under the Downs, at angles varying from 2° to 20°, and the rainfall over the area of their outcrop is high, being about forty inches per annum. Continuing now along the Western Railway Line we find that there is a gradual fall in the surface of the Downs, between Toowoomba and Roma, which is situated two hundred and seventeen miles further west. Thus, while the altitude of Toowoomba Railway Station is 1,921 feet, that of Roma is 978 feet.* The altitude of Gowrie Junction, only seven miles west of Toowoomba, is 1,577 feet, or only slightly more than that of Spring Bluff, where the porous sandstone outcrops.

It appears to me, therefore, that there is an area of country, having a width of about two hundred miles, and lying to the east of the outcrop of the Blythesdale Braystone, which, though hitherto unprospected, possesses all the conditions which are regarded as necessary to the occurrence of artesian water, and, in view of the recent discovery of a fine supply at Moree, in rocks of the same age as the Ipswich Coal-Measures, I am of opinion that the probabilities of artesian water being obtained in large quantities to the east of the outcrop of the Blythesdale Braystone are very strong indeed.

I have already quoted from Mr. Jack's paper, read before the Brisbane Meeting of the Australasian Association for the Advancement of Science, in which he drew attention to the porous nature of certain beds in the Trias-Jura formation, and to the probability of the water absorbed by them reinforcing the artesian supplies of the Lower Cretaceous formation. I not only concur in this opinion, but would even go so far as to suggest that the porous strata of the Trias-Jura formation may constitute the *chief* storage beds of the artesian water supply of Australia.

I am inclined to think that many of the successful bores in both New South Wales and Queensland may have obtained their artesian water, not altogether in the Lower Cretaceous rocks, but partly, and perhaps largely, in the underlying Ipswich Coal-Measures. Mr. Jack, in the interesting paper already quoted, speaks of unmistakable evidence of an unconformability between these two formations, and, in a sketch section, shows this unconformability to be so strong as to interrupt the continuity of the Trias-Jura formation; but, bearing in mind the very large area which the Ipswich Coal-Measures are known to occupy (with a more or less westerly dip) in the eastern portions of New South Wales and Queensland, and in view of the fact that at Leigh's Creek, near Lake Eyre, in South Australia, coal-bearing rocks have been identified by Mr. Robert Etheridge, Junior, as the

* Queensland Railways Time Table.

probable equivalents of the Ipswich Coal-Measures*—I consider that there are good reasons for believing that these Triassic or Jurassic Coal-Measures may be *continuous* under the Lower Cretaceous basin.

The occurrence of seams of coal in many of the artesian bores, both in Queensland and New South Wales, is also a matter which appears to bear upon the probability that, in many cases, sediments which have been regarded as Lower Cretaceous may really belong to the Ipswich Coal-Measures. So far as I am aware, the Rolling Downs formation in those localities, where *undoubted* sections have been examined, is essentially a marine deposit, and it appears more probable, therefore, that the coal-seams intersected in many of the bores, belong to the Ipswich beds, which we know to be coal-bearing, than to the Lower Cretaceous beds.

In the interests of geology it is is to be hoped that bores will soon be put down with drills capable of extracting a solid core, which would settle many of the vexed questions in connection with the geology of our Western Districts.

II.—Mineralogical and Petrological Notes, No. 4: by GEORGE W. CARD, A.R.S.M., F.G.S., Curator and Mineralogist.

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* Reports on Coal-bearing Area in Neighbourhood of Leigh's Creek, by H. Y. L. Brown, Adelaide, 1891. By Authority, p. 12.

1. *Magnesian alum-Pickeringite-from Capertee, and the Shoalhaven District.*—A magnesian alum from Mount Victoria, was recently referred to in these Records. * These all agree in consisting of aggregations of bundles of delicate silky fibres. The Shoalhaven mineral is described as occupying cracks in sandstone.

	1†	1A	2‡	A
Water (by difference)	45·79	46·49	42·37	43·12
Insoluble matter	1·51	....	1·74	....
Alumina (Al_2O_3)	7·14	7·25	10·91	11·10
Magnesia (MgO)	9·03	9·16	4·68	4·76
Potash (K_2O)	·32	·32	1·06	1·07
Soda ($N^d{}_2O$)	·53	·53	trace	trace
Sulphuric anhydride (SO_3)	35·68	36·23	38·14	38·82

1. Capertee. Analysis by Mr. J. C. H. Mingaye, F.C.S.
2. Shoalhaven. Analysis by Mr. H. P. White, F.C.S. This also contains ferric oxide, 0·21, lime, 0·30, manganous oxide, 0·59, and traces of the oxides of copper, nickel, and cobalt, and of chlorine.

1A, 2A. Percentage composition of the soluble portion of 1 and 2 respectively.

While the percentage of the magnesia in the Shoalhaven is normal, that from Capertee is unusually high.

Magnesium alums have been recorded under various names from the Cape Verde Islands, Chili, and elsewhere. It seems likely that some at least of these minerals are not homogenous.

2. *Tetradymite (?) from Tamworth.*—In August, 1894, Mr. G. A. Stonier, Geological Surveyor, collected some specimens of quartz from Moor Creek, Tamworth. These contained visible gold associated with a steel-gray mineral occurring in thin plates. The mineral is very soft, marking paper like graphite, and has a highly metallic lustre. The presence of tellurium and bismuth could be detected, but a quantity sufficient for analysis could not be obtained. The quartz is in part glassy and ironstained, and in part dull and dark green in colour, due to the presence of chloritic matter.

Tetradymite, together with its alteration product, montanite, has been recorded § as occurring in an ironstone gossan near Captain's Flat.

3. *A Diamond having the form of the Cube from South Africa.*—This was received by a Sydney diamond merchant in a parcel of "bort," and was acquired for the Mining Museum. The edges of the cube ($\infty O \infty$) are modified by a series of overlapping faces of the octahedron (O), giving rise to an appearance of a bevel such as would result from the presence of the rhombic-dodecahedron (∞O).

* Vol. IV., Pt. III, p. 133.
† 95/2443.
‡ 95/3022.
§ Rec. Geol. Surv. N. S. Wales, 1889, I., pp. 26-30.

The diamond has a grey tint; it measures 5 mm. in length of edge, and weighs 3·32 carats. There appear to be but few cases on record of a diamond having this form. Prof. G. F. Kunz has referred* to some Brazilian diamonds having the form of the cube. One of these had a diameter of four millimetres. Two were made up of a series of eight cubes aggregated together like a bale of cotton; others showed faces of the hexakis octahedron (**mOn**.)

4. *Stolzite and Nantokite from Broken Hill.*—This comparatively rare mineral, a tungstate of lead, is now being found in at least two different forms. One variety is of a gray colour, with a pearly lustre, and resembles the head of a nail in appearance; the crystals consisting of faces of the tetragonal prism terminated by a low pyramid of the same order.

The other variety is found apparently only in the Open Cut at the Proprietary Mine. It is yellow-brown in colour, and the crystals consist essentially of the tetragonal pyramid. The basal plane and a pyramid of different order are sometimes present. One of the largest crystals has a length of nearly a centimetre.

A massive form of stolzite, intimately associated with scheelite and cuproscheelite, occurs at Peelwood.

Nantokite (Cuprous choride) has been described† by Prof. A. Liversidge, M.A., F.R.S. The oxidation of this mineral to atacamite (oxy-chloride of copper) is very rapid. Attempts were made to retard this action by saturating the specimens with paraffin wax, and sealing up in glass-capped boxes. This has only been partially successful.

5. *Crystallised Gold from Grong Grong.*—Some ferruginous quartz from Grong Grong shows gold finely dusted over the surface. On examination with a powerful pocket lens this "dust" is seen to consist of individual crystals. Under the microscope many of these crystals are seen to have been damaged by friction against other specimens. Their average size would be, approximately, somewhere about one-twentieth of a millimetre. The crystalline form has not as yet been satisfactorily made out; but faces of the cube, the rhombic-dodecahedron, and of the octahedron appear to be present.

6. *Antimonial and Arsenical Silver Ores from Armidale.*—These ores have hitherto been known to occur at Rivertree, near Drake, and then only in very small quantities. They have now been found in veins and patches of considerable size associated with arsenical pyrites and blende in the vicinity of Rockvale, Armidale. The antimonial varieties would appear to predominate over the arsenical, only one specimen of proustite having been received up to the present. Stephanite is said to occur, and a small specimen resembling somewhat the polybasite of Mexico, but containing no copper, is probably that mineral. The occurrence of crystallised specimens has not yet been recorded.

* Quoted in the Engineering and Mining Journal for 18th Sept., 1886.
† Min. Mag., 1894, X, p. 326.

Two specimens of massive arsenical pyrites, in which the silver minerals could not be readily detected, were found to contain, respectively, seven hundred and seventy-nine and eight hundred and sixty-two ounces of silver to the ton. Two other specimens, in which pyrargyrite was freely visible, yielded respectively, on assay, silver at the rate of 1,885 oz. and 2,341 oz. per ton.

Lumps of pure pyrargyrite of considerable size have been found. Native silver occurs in the form of spongy masses made up of delicate filamentous growths, and also as thin encrustations.

7. *Trachytic Tuff from the Manning River District.*—This [745] is an earthy white rock containing numerous crystals of sanidine, and enclosing angular fragments of shaly material. The sanidine crystals are numerous, but small—up to 5 mm. in length—and are of the usual tabular habit. The included fragments vary in size from half an inch downwards.

Under the microscope the sanidine crystals are seen to be idiomorphic, but somewhat corroded. They contain a variety of inclusions, and have a tendency to assume orthopinacoidal sections. The base is dusky and spotted. Examined under high powers, it is seen to consist of dusky particles and wisps and shreds of glass.

Trachytic rocks have, up to the present, been recorded (in New South Wales) only from the Warrumbungle Mountains*.

8. *An Acid Tuff from Rudder Hill, Macleay River.*—This [622-3-4] is a compact gray rock, weathering brown and white. With a lens of low power, it is seen to contain numerous angular fragments of colourless translucent quartz. A polished surface reveals various shades of gray, and, in addition to the quartz grains just alluded to, numerous specks of pyrites and angular included fragments of considerable size. Some of these inclusions are lighter, others darker, than the ground-mass. One of the larger fragments measures twelve millimetres by nine. Bands and patches of a lighter colour occur in the ground-mass.

Under the microscope the included fragments are found to consist of quartz, devitrified glass, and to a less extent of crypto-crystalline volcanic rocks.

The specific gravity of an unweathered chip, determined by the Joly Balance, is is 2·75.

9. *Rocks from Binalong.*—A series of four rocks collected by Mr. J. E. Carne, Geological Surveyor, early in 1894.

[497] A *quartz-diorite* consisting of hornblende, striped felspar, and quartz. Much of the hornblende is idiomorphic, both green and brown varieties being present. Secondary outgrowths of clear material surround most of the felspar, the original portion of crystals being converted into kaolin, epidote, &c. Quartz is fairly abundant.

* These Records, Vol. IV, Pt. III. The Trachytic Rock therein described has been proved by Prof. T. W. E David to be a silicified portion of a crystal-tuff.

The remaining rocks—[494-5-6]—consist of devitrified *felspar porphyries*. Corroded crystals of quartz and felspar are embedded in a more or less felsitic matrix. Hornblende is absent, the ferro-magnesian constituent being biotite—much corroded, and to a large extent recrystallised. The ground-mass is completely micro-crystalline, much of it appearing as a water-clear mosaic between crossed nicols, and has a general brownish tint due to the development in it of flakes of mica.

The felspar is tolerably clear, zoned, and is mostly, if not entirely, plagioclase. The phenocrysts are surrounded by a clear space in the matrix. Quartz in secondary aggregates and magnetite in the biotite are also present.

In places the base exhibits a curvilinear appearance outlined with flakes of mica. There can be little doubt that this represents an original perlitic structure.

10. *Rocks from the Coramba Gold-fields.*—Coramba is situated some twelve miles westerly from Woolgoolga, in the Grafton District. The rocks now briefly referred to were collected by Mr. J. E. Carne, F.G.S., Geological Surveyor, in November, 1895.

The country rock [736], exemplified by specimens from Tallawudjah, is a compact buff-coloured sedimentary rock, consisting of sub-angular fragments of quartz and felspar set in a yellowish matrix.

The remaining samples consist of granites and, perhaps, porphyries, presumably intrusive in the country rock.

[740] is a crushed *granite* consisting essentially of fractured or comminuted quartz and felspar. Much of the felspar exhibits lamellar twinning, and in some of these the twin lamellæ are bent, or faulted so as to resemble nothing so much as a section in miniature through a Belgian Coal-field.

Macroscopically, the rock has more the appearance of a crushed felsite. From the Evening Star Claim is a somewhat similar rock [739]. In hand-specimens of these the constituent minerals are not readily recognised. This is different, however, in the case of a rock from the Coramba King Mine [738]. This rock has more the appearance of a porphyry; crystals of dead-white felspar and blebs of glassy quartz being embedded in what appears to be a greenish felsitic base. The internal evidences of crushing are much less marked than in the rocks already referred to. A little brown hornblende is present; and this has been stretched and disrupted by crushing.

[737] From the Lady Elsie Claim is a more or less fissile rock resembling [738].

11. *Rocks from the Cinnabar Mines, Yulgilbar, near Lionsville.*—The notes refer to rocks collected by Mr. J. E. Carne, F.G.S., Geological Surveyor, in October, 1895.*

* See forthcoming Ann. Rept. Dept. Mines for 1895.

[733, 734] From No. 2 Shaft. Fine-grained *augite-diorites.* Compact dark-green pyritous rocks, apparently having a slight tendency to fissility.

The minerals present are tolerably clear felspar, showing lamellar twinning; pale-green hornblende with a tendency to develop idiomorphic crystals on the one hand, and ophitic structure with regard to the felspar on the other; chloritic products resulting from the alteration of hornblende; a little colourless granular augite; magnetite developing in the hornblende which is somewhat bleached in consequence.

[734] Country Rock. *Granitite* (of G. Rose). Quartz; felspar—orthoclase and repeatedly twinned varieties (oligoclase probably); a little hornblende; a very little magnetite.

The larger felspar crystals are very clearly zoned; they are somewhat altered. The hornblende is more or less idiomorphic.

[744] This would appear to be identical with [734]. The constituents are, however, very much weathered; and this alteration has been accompanied by an introduction of cinnabar. This mineral occurs in scattered grains in the felspars, and in more or less continuous strings in the hornblende following the divisional planes.

[735] A compact greenish-coloured *felsite* weathering brown.

[741] Pyritous *felsite* with secondary quartz, calcite, and cinnabar. From No. 2 Shaft.

[742] From fifty-foot level; similar to [741].

12. *A Peridotite from Gundagai.*—This note has reference to a specimen [620] collected at the "Emu" chrome-iron ore mine at Gundagai, by Mr. J. E. Carne, F.G.S., Geological Surveyor, in 1895. At that particular mine the peridotite would appear to constitute the matrix in which the ore occurs. Macroscopically the rock is dense, tough, and of a blackish-green colour, translucent in thin splinters (and green by transmitted light). On the joint faces that bound the specimen is a coating of smooth reedy serpentine. Here and there are visible faces of a fibrous mineral not differing much in colour from the mass of the rock. Under the microscope the rock is found to consist of fresh *olivine* traversed in all directions by thin veins of a pale yellowish-green limpid *serpentine* quite free from magnetite. Accompanying the olivine is a *rhombic pyroxene* which is passing into the *bastite* modification, *chrome spinel*, and (probably) *chromite.* The pyroxene occurs in massive colourless crystals; prismatic cleavage is ill-defined, pleochroism is feebly indicated by a variation in illumination when rotated over the lower nicol, extinction is parallel to the trace of the pinacoidal cleavage, refractive index high, double refraction weak and apparently positive. The development of bastite has gone on more especially in the vicinity of transverse cracks to which the

fibres are set at right angles. Between crossed nicols much of the pyroxene is seen to possess a lamellar structure, a series of narrow, parallel (straight or curved) bands, sometimes consisting of drawn-out lenticles, extinguishing at a different angle to, and sometimes polarising in more vivid colours than the crystal. The extinction angle of the lamellæ is in some cases very oblique. There would thus appear to be an intergrowth of pyroxenic minerals, a nonoclinic variety being represented by the obliquely extinguishing lenticles. Although satisfactory cleavage flakes could not be obtained for examination in convergent light, the mineral may perhaps be regarded as *bronzite* in which a change to *bastite* is in progress.

Consisting as it does of olivine with some rhombic pyroxene and a little spinellid, the rock can be best classed as a peridoxite. It is of interest as being apparently the first unaltered representative of this group to be recorded as occurring in New South Wales. Its dense compact nature renders its appearance very distinct from that of the now well-known olivine-rock, dunite, from New Zealand. The occurrence of peridotites at the Gundagai Chrome Mines points to the probability of the serpentines and chrome deposits of this district having originated in what is generally regarded as the normal way—from olivine; a point of interest in view of the clear evidence now being collected* by my colleague, Mr. J. B. Jaquet, A.R.S.M., F.G.S., that the serpentines of some other districts of New South Wales, and among others the chrome-bearing serpentines of Berthong in the Wallendbeen District, have originated mainly if not entirely from amphibole.

13. *Rocks from the Cox River.*—A series of six intrusive igneous rocks collected from the bed of the Cox River, below Hartley, by Mr. H. G. Rienits and Mr. Clive Ball, to whom is due the description of the mode of occurrence of the rocks. On striking the Cox River one mile below Littleton Homestead, a few miles west of Hartley, the rock is a grey granite [638], traversed in a north-east and south-west direction by a vein of tourmaline from one to four inches thick. In about fifty yards this is replaced by a pink aplite [640], traversed by veins of pegmatite containing tourmaline [641]. Two hundred yards further on is a pinkish felsite [642] extending for about half a mile. The felsite contains balls of granite from one to three inches in diameter; these weather out, leaving globular cavities. A quartz-diorite [643] succeeds the felsite, and extends for a quarter of a mile. After passing over a hard sedimentary rock with fossiliferous bands for some two miles the quartz-diorite [645] again crops out, and an east to west dyke of that rock has given rise to various secondary minerals—wollastonite, garnet, quartz—by contact metamorphism in the country rock. Graphic granite [646] is met with still further on.†

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* Geology of the Broken Hill Lode. Sydney, 1894, p. 58.

† Since writing this description the Writer has paid a brief visit to the locality under the guidance of the above-mentioned gentlemen. The distances given must be regarded as very approximate. The fossiliferous rock is quartzite of Devonian age, and may, perhaps, be regarded as an easterly extension of the Mount Lambie beds. The Geological Survey is much indebted to Mr. Rienits for much valued assistance.

The diorites, especially perhaps [643], are more typical representatives of their class than most of those generally known to occur in the Colony, and should be useful for educational purposes.

[638.] May be described as a rather basic *granite.* The minerals present are quartz, much white and pinkish-white felspar, biotite, sphene, apatite, and magnetite. Some of the felspar is triclinic. Small crystals of sphene can be detected by the unaided eye.

[640.] A fine-grained granulitic pinkish *aplite*, consisting of quartz and felspar (some triclinic) with a little mica. A micro-graphic structure is present.

[641.] *Pegmatite* with much pink felspar and black tourmaline (schorl); a little mica is also present. This occurs as veins in [640].

[642.] Pinkish *felsite* consisting of small phenocrysts of quartz and felspar in a thoroughly devitrified base. Between crossed nicols the mosaic-like base can be readily resolved into its constituents.

[643.] *Quartz-diorite*, consisting of felspar, green hornblende (sometimes with a bluish tint), a little quartz, and sphene occurring in minute crystals scattered abundantly through the rock, and contained by the hornblende. Pyrites occurs as a secondary mineral associated with the hornblende.

[645.] *Quartz-mica-diorite*, not quite so fine-grained as the preceding, and without sphene. Much of the felspar is beautifully zoned. Apatite is abundant. The biotite would appear to have developed to some extent subsequent to and at the expense of the hornblende.

14. *Norite from Wyalong.*—Among the rocks collected from the Wyalong Gold-field on two successive visits by the Government Geologist are two which from their silica content and mineral constituents must be classed as *hypersthene-gabbro* or *norite.* The bulk of the rocks collected consist of gneissic granitites, diorites, and quartz-diorites, and a general description of these will shortly appear in these Records. Meanwhile it is desirable to record the occurrence of this interesting rock. The norite is a medium-grained dark-gray rock, having a specific gravity of 2·76*, and a silica percentage of 50·60*. The minerals present are *plagioclase felspar, hypersthene, hornblende, magnetite, zircon, apatite,* and probably *quartz.* The felspar which is fresh and abundant has not yet been determined. Twinning is almost entirely on the albite type; and the felspar is to some extent schillerized. Hypersthene is very representative, exhibiting the characteristic pleochroism, cleavage, outline, and straight extinctions. A paramorphic (?) change to hornblende can be traced step by step from a peripheral fringe of fibrous material to crystals of hornblende containing residual hypersthene and, by inference, to hornblende in

* Determined respectively by Mr. M. Morrison and Mr. H. P. White.

which the transition is complete. There would appear to be a close analogy between the changes here referred to and those described by Williams and Chester in the norites of Baltimore and Delaware respectively. The hypersthene is traversed by deeply-stained cracks. The hornblende is generally green in colour and exhibits well-developed cleavage cracks when of appreciable mass. It is probably entirely secondary.

III.—Palæontologia Novæ Cambriæ Meridionalis.—Occasional Descriptions of New South Wales Fossils, No. 2: by R. ETHERIDGE, Junr., Curator of the Australian Museum.

(*Continued from Vol. IV., Pt. I, p.* 37.)

[Plate I.]

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1. *Genus* PLATYCERAS, *Conrad.*

THE species of this very protean genus have been variously grouped and arranged by authors, either in structural groups, such as *spinosi*, *annulati*, &c.; as sub-generic sections under the genus in chief, or as the latter in the light of genera pure and simple.

As sub-generic sections the chief are:—

a. PLATYCERAS, Conrad (= *Acroculia*, Phill.)—Apex incurved or spirally coiled; surface concentrically striate, radiately plicate, or spiniferous.

b. ORTHONYCHIA, Hall.—Shell arched or straight, elongately conical; the apex recurved but not spiral or enrolled; surface concentrically striate.

c. IGOCERAS, Hall.—Resembling *b*, but the surface cancellate.

d. EXOGYROCERAS, Meek and Worthen.—Shell with a sinistral coil, and an obscure columella.

These sectional divisions are only of use in extreme forms, as it is often difficult, remark Messrs. Meek and Worthen, to separate them, owing to gradations by which they blend into one another.*

Four species have been described from the Permo-Carboniferous rocks of New South Wales, two by Dana, and two by De Koninck. Both of Dana's (*Pileopsis tenella* and *P. alta*), as he termed them, are difficult of determination from their comparatively small size; while De Koninck's species are European forms recognised as Australian—*Platyceras augustum*, Phill., and *P. trilobatum*, Phill. The

* Illinois Geol. Survey Report, 1868, III, p. 387.

first of these is a synonym of *P. auricularis*, Martin, and the second of *P. vetustus*, Sby, and both appertain to the section *Platyceras* proper. As regards Dana's specimens, one (*P. tenella*) is an abnormally depressed form for this genus ; the other (*P. altum*), referable to the section *Orthonychia*, I believe I have recognised in a fossil collected by Mr. John Waterhouse, M.A., and presented by him to the Collection.

Platyceras (*Orthonychia*) *altum*, Dana?

Pl. I, Figs. 1 and 2.

Pileopsis alta, Dana, Wilkes' U.S. Explor. Expd., 1849, x. (Geology), p. 706, Atlas, t. 9, f. 14.

Sp. Char.—Shell cornute and much curved, acuminate above, non-lobate, and laterally compressed ; height slightly greater than the antero-posterior diameter of the mouth ; sides flattened ; apex acute, much re-curved and inclined downwards, overhanging, central to the general plane of the shell, or excentric ; anterior outline convex and strongly curved ; mouth elliptical, in one plane, antero-posterior diameter rather more than one-third greater than the transverse ; peristome entire, without sinuosity or expansion, the anterior margin rounded, lateral margins almost straight, and the posterior very slightly truncate. Surface with concentric laminations of growth, with intermediate fine striæ, crossed by the finest possible continuous striæ in the direction of the growth.

Obs.—In consequence of the small size of Dana's *P. altum*, it is difficult to surmise whether the present fossil, represented in Pl. I Figs. 1 and 2, is that species or not, a difficulty not lessened by the known variability of the species of the genus. However, if the degree of curvature of the shell can be accepted as any criterion, I think that Pl. I Figs. 1 and 2, may be accepted as *P. altum*, Dana, although it may be pointed out that the apex in the latter is not bent downward to the same extent as in the specimen now under description. At the same time one fact may be noted in favour of the view now adopted, both come from the same locality and horizon.

Loc. and Horizon.—Harper's Hill, near West Maitland, and Rutherford, three and a half miles from West Maitland; Lower Marine Series, Permo-Carboniferous. Collected by Mr. J. Waterhouse, M.A., and presented by him to the Mining and Geological Museum, with the succeeding specimens.

Platyceras (*Orthonychia*) *cornu-capellæ*, sp. nov.

Pl. I, Fig. 3.

Sp. Char.—Shell cornute, narrow, more or less curved, acuminate above, laterally compressed; height equal to the antero-posterior diameter of the mouth; apex acute, but not overhanging as in the last species, apparently in the central line of

the shell; anterior outline convex, curved; mouth elliptical, in one plane, antero-posterior diameter nearly double the transverse; anterior outline convex, curved; front narrow, the margin rounded; sides flattened, with rather straight margins; posterior slope flattened, the outline somewhat concave, and the margin slightly truncate; surface bearing subangular somewhat gradate concentric ridges, with concave interspaces, both traversed by concentric fine striæ, and crossed by other microscopically fine striæ in the direction of growth.

Obs.—Although there are well marked points of difference between this and *P. altum*, Dana, such as the gradate concentric ridges, much longer mouth fore and aft, and a less bent down apex, it is possibly only a variety of that species, for reasons already explained. It accords rather better with De Koninck's figure * of *P. altum*, than it does with Dana's, and I therefore prefer, for the present at least, to consider it distinct, this being, I believe, the safer course. Both this and the last species described are remarkable for the regularity of their growth, and the outline of their peristomes.

Loc. and Horizon.—Harper's Hill, near West Maitland; Lower Marine Series, Permo-Carboniferous. Collected by Mr. J. Waterhouse, M.A.

Platyceras (*Orthonychia*) *ungula*, sp. nov.

Pl. I, Fig. 4.

Sp. Char.—Shell short, conical, hardly curved, obtusely acuminate, scarcely compressed laterally; height quite one-third less than the longest diameter of the mouth, but equal to the transverse measurement of the latter; apex obtuse, sub-central, not overhanging the posterior margin; anterior outline slightly curved; sides more convex than in either of the preceding species; posterior slope slightly convex, not flattened; mouth oval, in one plane, antero-posterior diameter somewhat greater than the transverse; peristome entire; surface with a few irregular concentric ridges, and intermediate finer lines, crossed by microscopically fine striæ.

Obs.—This is a very different form to either *P. cornu-capella* or *P. altum*, much shorter vertically, conical instead of cornute, and with an oval instead of an elliptical mouth. It is also distinct from Dana's *P. tenellum*, and both of the European species described by De Koninck.

There is a curious resemblance in *P. ungula* to many of the straight conical species figured by Barrois from the Devonian rocks of Erbray, France, † and rocks of similar age in North America, illustrated by Hall, rather than to ordinary Carboniferous forms.

Loc. and Horizon.—Harper's Hill, near West Maitland; Lower Marine Series, Permo-Carboniferous. Collected by Mr. J. Waterhouse, M.A.

* Foss. Pal. Nouv.-Galles du Sud, Pt. 3, 1877, t. 23, f. 5.
† Faune Calc. d' Erbray, 1889, t. 12 and 13.

2.—*Genus* EUOMPHALUS, *J. Sowerby*, 1814.*

(Min. Con., I, p. 97.)

Euomphalus cera, † sp. nov.

Pl. I, Figs. 5 and 6.

Sp. Char.—Shell depressed, discoidal, wafer-like, of four or five whorls, the inner ones on the upper side of the shell sunk completely below the edge of the body whorl, and their surfaces sloping inwards; section of whorls oval; suture rather channelled; an obtuse keel on the edge of each whorl; back of the body whorl rounded, or very slightly angulated.

Obs.—The mouth of this shell is unfortunately not preserved, and there does not appear to be any sculpture. The present species, even amongst so depressed a group of shells as those composing *Euomphalus*, is remarkable for the degree of compression attained by it, and does not seem to have any very definite allies. No true *Euomphalus* has so far been figured from the Carboniferous or Permo-Carboniferous of New South Wales, but more than one species is now known to have existed. A so-called species was long ago described by M'Coy as *E. minimus* ‡, but without a re-examination it is impossible to say what the shell included under this name may be. The shell figured by De Koninck § as *E. catillus*, Martin, a European species, is a very questionable determination, and is probably referable to some other genus. *Euomphali*, of the Group of *E. pentangulatus*, Sby., exist in the Queensland Gympie Series.

Loc. and Horizon.—Seven miles north-east of Paterson on the Dungog-Paterson Road. Mirari Limestone, Carboniferous. Collected by Mr. J. Waterhouse, M.A.

3.—*Genus* MOURLONIA, *De Koninck*, 1883.

(Faune Calc. Carb. Belgique, 1883, Pt. 4, p. 75.)

Mourlonia? Waterhousei, sp. nov.

Pl. I, Figs. 7 and 8.

Sp. Char.—Shell depressed turrited, deeply umbilicate; whorls four (as far as preserved); upper whorls nearly straight-walled, flat and tabulate above, sharply keeled at the peripheries; body whorl generally rounded above and below, bearing three spiral keels, one peripheral in position, a second supra-peripheral, and a third similar, but rather more widely separated from the second than the first and second are from one another; surface, except the space between the first and second keels, which is concave and plain, transversed by spiral raised lines, with traces of indistinct obtuse, or flattened varices, especially on the body whorl.

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* Restricted, De Koninck, 1881, Faune Calc. Carb. Belgique, 1881, Pt. 2, p. 136.
† *Cera* a wafer.
‡ Ann. Mag. Nat. Hist., 1847, XX, p. 306, t. 17, f. 4.
§ Foss. Pal. Nouv.-Galles du Sud 1877, Pt. 3, t. 23, f. 19.

Obs.—The mouth and apex are not preserved; but, I think, a small fifth whorl existed. The concave space between the peripheral and second spiral keel has very much the appearance of a band, which I believe existed in this shell, although from the imperfection of the peristome, no trace of the sinus now exists. On these characters very much depends the systematic position of *Mourlonia*.

At first sight it is not dissimilar to the tabulate *Euomphali*, but the existence of a band, presuming my supposition to be correct, will tend to remove the shell to the Pleurotomariidæ. Adopting this view, then it may be safely stated that no other Australian Palæozoic shell approaches the present species nearer than *Mourlonia subcancellata*, Morris, sp.,* also a more or less tabulate form. In the latter, however, the whorls are much rounder, and proportionately larger, there exists a narrow convex peripheral band on the body whorl, and the whole surface carries a cancellated sculpture.

Loc. and Horizon.—A quarter of a mile north-west of the Water-works, West Maitland; Upper Marine Series, Permo-Carboniferous, named in honour of Mr. J. Waterhouse, M.A., who collected the specimens.

IV.—The Intrusive and Metamorphic Rocks of Berthong, Co. Bland, N. S. Wales, with especial reference to the Occurrence of Serpentine after Amphibolite: by J. B. JAQUET, A.R.S.M., F.G.S., Geological Surveyor.

[Plate II.]

BERTHONG ESTATE is distant about nine miles in a northerly direction from Wallendbeen, and twenty miles in a north-easterly direction from Cootamundra. It is owned by Mr. James Gibb.

The formations represented are as follows:—

SEDIMENTARY.

Silurian.

Slates and Quartzites.

Post Tertiary.

Gravels and Clays.

* Strzelecki's Phys. Descrip. N. S. Wales, &c., 1845, t. 18, f. 6.

Intrusive.

Acid.

Granitite.
Eurite.

Ultra-basic.

Amphibolite.
Serpentine.
Diallage rock.

The Silurian slates are much cleaved and otherwise altered. Quartz veins run through them, and some of these veins have been found to contain gold, though not in payable quantities. Large masses or beds of magnetite, with an admixture of quartz occur near the Homestead, and the highly ferruginous character of the soil in the Cultivation Paddock is due to weathered iron-ore which has been washed down from the hills above.

Granitite.

The western boundary of that great boss of granite which runs from near Grenfell in the north, through Young and Murrumburrah to Jugiong in the south, and covers altogether about a thousand square miles of country, passes through the Estate.

The description which is given below shows the rock at Berthong to be referable to the basic granites or granitites; and near Young, a town distant twenty miles, it would seem to be of a similar character since the late Mr. C. S. Wilkinson writes of it as containing hornblende.*

The rock has a specific gravity of 2·73. Examined microscopically it is seen to consist of felspar and quartz with abundant plates of dark mica. It generally shows some sign of lamination, and not infrequently has been changed into a perfect gneiss.

Under the microscope the felspars are seen to all belong to the triclinic variety. Some of them are altering into a felted mass consisting of minute mica fibres, and others have been replaced by fibrous mica altogether. These mica aggregates resemble those which I have described and had figured as occurring in a crushed granitite from the Barrier Ranges.†

The primary mica consists chiefly of biotite, though occasional plates of muscovite are present. The dark mica often includes numerous minute rods of rutile which run in three directions and cross one another at 60°.

Even specimens which appear unaltered to the naked eye yield, when the microscope is brought to bear upon them, abundant evidence of the crushing to which they have been subjected. The quartz appears in the form of rounded granules, which, being grouped together, give rise to mosaics; while plates of mica and felspar lamellæ are bent and twisted, and in some instances broken.

* Ann. Rept. Dept. Mines for 1876 [1877], p. 154.
† Geology of Broken Hill Lode, p. 59.

Eurite.

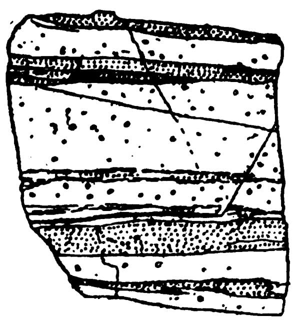
A small boss of this rock is to be found a few chains north of the point where Berthong Creek crosses the southern boundary of Portion 640. (Pl. II.)

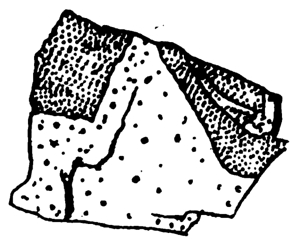
It possesses a pale yellow colour and has a specific gravity of 2·61.

Examined microscopically it is seen to be composed of grains of quartz and felspar imbedded in a microcrystalline base. The quartz grains often enclose sheath-like bundles of acicular crystals. The felspars are much decomposed, and many of them exhibit a zonal structure. They sometimes belong to the monoclinic and sometimes to the triclinic variety.

Some specimens which I collected from a point where this rock abuts upon the amphibolites have ragged fragments, and less commonly rounded grains of hornblende scattered in an irregular manner through them. In the same locality bands of a dark green colour occasionally traverse the rock. The microscope shows these bands to differ from the remainder of the mass in containing a much greater number of rounded hornblende grains, which in many instances can be seen flowing round the authigenic felspars. All the circumstances point, I think, to the hornblende grains having had a foreign origin; they were probably derived from the amphibolite at the period of intrusion. Fig. 1 represents a specimen cut from the

FIG. 1. Natural size. FIG. 2.





banded rock. In Fig. 2 the eurite is seen sending a small apophysis into the amphibolite. Under the microscope the latter rock appears to be completely altered. It is composed of broken hornblende grains imbedded in a quartzo-felspathic base. Fragments of hornblende are also to be found in the eurite. The intruder would seem here to be exposed in the act of breaking down, and possibly absorbing, masses of the rock it was intruding.

Amphibolite.

This rock, and the serpentine which is associated with it, occur in a shallow basin at the head of Berthong Creek. Dykes of hornblende rock are also to be found in the Silurian slates.

In places the rock is more or less foliated, and might perhaps be described as a hornblende schist, while elsewhere it shows no sign of lamination. Again the components are for the most part of a small size, though from the centrally situated portions hornblende grains half-an-inch or more in length can be obtained.

When examined in thin sections under the microscope the rock is seen to be essentially made up of hornblende grains with a little accessory magnetite and rarely chromite. Some slides show no evidence of dynamo-metamorphic action at all; in others the hornblende has been rolled out and crushed; while in extreme cases the individual grains have lost their identity and are now represented by a more or less confused aggregate of fibres.

Serpentine.

Upon the Geological Map of the Colony serpentine is indicated as being present in the vicinity of Gundagai, Lucknow, Solferino, Oberon, and Bingera, in the Eastern Division. Mention is made of these rocks in various official reports, but no one, so far as I am aware, has given a detailed description of their petrographical character or the relations which exist between them and accompanying formations.

Professor T. W. E. David, when referring to the Bingera serpentine in his report upon a deposit of cinnabar in that locality says that "it results from the alteration of an ultra-basic rock of a decidedly intrusive character." * Professor J. W. Judd in a paper recently read before the Mineralogical Society describes two interesting rocks, which occur as dykes in this serpentine.† One of them is composed of green garnet and the other of picotite.

In the Collection of the Geological Survey I found specimens of the Bingera rock. It has a mottled green and yellowish-white colour. Dark glistening grains exhibiting a fibrous structure are present in considerable numbers. It polishes well, and forms an ornamental stone of some beauty. The microscope shows it to be composed of serpentine with grains of bastite and picotite (slides 128a and 128b)‡ A very complete "maschen-structur" is to be seen, so this serpentine has probably been derived from a rock rich in olivine. Mr. P. T. Hammond after making an examination of the Gundagai serpentine in the field, writes of it as having been derived from the "decomposition *in situ* of a basic eruptive rock which has been intruded along the bedding planes of the slates." §My Colleague, Mr. G. W. Card, Curator and Mineralogist, has recorded the occurrence of an olivine rock from near Gundagai, which may have been the precursor of the serpentine.||

* Ann. Rept. Dept. Mines and Agric. for 1891, [1890]. p, 235.
† Min. Mag., XI, No. 50, p. 63.
‡ The numbers are those in the Geological Survey Collection.
§ Records Geol. Survey N. S. Wales, III, Pt. 1, p. 20.
|| *Antea*, p. 11.

One occurrence of serpentine has been recorded from near Broken Hill, in the Western District of the Colony. This rock has already been described by the Writer.* It contains numerous more or less serpentinised hornblende grains; and a chemical analysis showed the rock to differ from a normal serpentine in containing a considerable quantity of alumina and lime. It would seem to belong to those rarer serpentines after hornblende, and hence has a close affinity to the rock about to be described.

The Berthong serpentine is closely associated with the amphibolite. This circumstance, and the fact that no other possible parent rock is to be found in the vicinity, suggests that the former rock has been derived by a metasomatic process from the latter; and a microscopic examination would seem to confirm this view.

Unfortunately the serpentine is much hidden by a shallow alluvial deposit, which renders the relation which it bears to other rocks somewhat difficult of elucidation in the field. The best sections obtainable are along the course of Berthong Creek. There alternate outcrops of serpentine and amphibolite can be seen, but in no place did I see a line of junction exposed.

The rock in the rough has a dark gray or greenish-gray colour. Polished specimens show a dark gray ground with patches of olive-green and occasional faint tints of red. The appearance of the rock is probably too dark and sombre to cause it to be sought after for decorative purposes. Thin layers of marmolite with a bluish-white colour and pearly lustre are found upon some of the joint planes.

Over considerable areas the rock has been much weathered; sometimes to such an extent that it can hardly be recognised. The weathered portions are impregnated with ferric oxide. In places they include pockets and anastomosing veins of chalcedony.

The serpentine is for the most part homogeneous, and exhibits no sign of mechanical deformation. A schistose structure is, however, occasionally present. In the immediate vicinity of the diallage rock described hereafter foliated serpentine, accompanied by bands of talc-schist, occurs.

Deposits of chromite† of a payable character have been discovered in the bed of Berthong Creek. A thin vein of asbestos has also been found in the serpentine. I have already reported upon the occurrence of these economic minerals.‡

Under the microscope, by transmitted light, the serpentine presents for the most part a pellucid, homogeneous appearance. It is generally faintly stained with ferric oxide. Chromite and magnetite are invariably present.

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* Geology of Broken Hill Lode, p. 57.

† The chromite is associated with both serpentine and unaltered amphibolite. Slide 692 is composed of chromite and grains of pale-green hornblende.

‡ Ann. Rept. Dept. Mines and Agric. for 1895, *in litt.*

These ores are generally found in a broken network which follows original hornblende cleavage planes (Slide 680) or other lines of parting in the rock.

Between crossed nicols the clear mass is resolved into a number of short polarising fibres with isotropic material between. No mesh structure can be observed; nor would the rock seem to resemble in any way a serpentine after olivine. On the other hand the lattice structure, so characteristic of hornblende-serpentine, can be seen; and upon rotating the stage, the boundaries of original hornblende grains can be distinguished by the simultaneous extinction of the material within them.

In one of the slides (No. 680) grains of but little-altered hornblende, with cross-sections showing a well-defined cleavage, occur in a matrix of serpentine.

Analyses of the serpentine and the adjacent amphibolite from which it has been derived have been made by Mr. J. C. H. Mingaye, F.C.S., Analyst to the Mines Department, and are as follows :—

	Serpentine.		Amphibolite.
Moisture at 100° C	2·87	......	·26
Combined water	10·11	......	·79
$Si O_2$	40·80	......	49·30
$Al_2 O_3$	2·54	......	10·42
$Fe_2 O_3$	6·20	......	2·20
Fe O	·48	......	3·83
Mn O	trace.	......	absent.
$Cr_2 O_3$	·29	......	trace.
Co O and Ni O	·25	......	trace.
Ca O	absent.	......	11·82
Mg O	32·82	......	19·36
$Na_2 O$	·27	......	1·14
$K_2 O$	absent.	......	·50
	99·63		99·62
Spec. grav.	2·52		3·00

The analysis shows that the altered rock is a perfect serpentine, and that the parent hornblende was, comparatively speaking, rich in alumina.

Mr. G. F. Becker states—"That Breithaupt is said to have been the first to detect the pseudomorphosis of serpentine after hornblende."* Wiegand, working upon the rocks at Rauenthal in the Vosges in 1875, investigated and described a serpentine after an aluminous hornblende.† He found, upon analysis, that this rock contained a considerable quantity of residual alumina; and he afterwards proved, by treating it with hydrochloric acid and analysing both the soluble and insoluble portions, that it consisted of serpentine with grains of chlorite in which the alumina was present.

* Becker, Geology of the Quicksilver Deposits of the Pacific Slope. U.S. Geol. Survey, Mon. XIII., p. 118.
† Tschermak, Min. u Petrogr. Mittheil., Vienna, 1875, p. 183 (quoted by Teall, British Petrography, p. 110.

Prof. T. G. Bonney has contributed an article to the *Geological Magazine*, in which he discredits many of the conclusions arrived at by Herr Wiegand.* After examining microscopic slides of the Rauenthal rock, he states that while admitting that it contains hornblende which has been transformed into a "serpentinous mineral," yet he is of opinion that the great bulk of the rock represents altered olivine. He opines, in fact, that the parent rock was a hornblende-peridotite, rather than an amphibolite. If Prof. Bonney be correct in his assumption we should expect to find some olivine in the adjacent hornblende rocks, but Herr Wiegand does not report this mineral as being present.

If we admit that under favourable conditions hornblende will undergo a serpentinous alteration—and there would seem to be overwhelming evidence in favour of such an hypothesis—then I fail to see any difficulty in conceiving an extreme case where the change has been a complete one. No one, I think, could view sections of the Berthong rock between crossed nicols without admitting that it had been derived from a rock essentially composed of hornblende; and this rock has the composition of a normal serpentine. In other words, we have conclusive evidence that hornblende has been in this instance completely transformed into serpentine. We can, in the present state of our knowledge, only conjecture as to the circumstances which premit of such a change taking place, involving as it does the removal of alumina and silica in solution. We cannot exactly simulate in the laboratory the physical conditions which may obtain at a great depth beneath the earth's surface; nor is it permitted to us, nor our race, to live long enough to record the effect of insignificant chemical affinities acting over vast periods of time. However, we know that both silica and alumina† are dissolved in some spring-waters, and we have reason to believe from their mode of occurrence that many alums have originally been deposited from solution.

Diallage Rock.

Near the "Lick-hole," at the spot indicated upon the accompanying map, there is a small outcrop of this rock, which is bounded upon one side by serpentine, and upon the other by amphibolite. The exact area which it covers cannot be determined on account of the boundaries being hidden by alluvium.

As seen in the field it consists of a number of glistening brown grains which stand out from a dark-gray base. The specific gravity averages 3·04.

Under the microscope, by transmitted light, the diallage grains are seen in some instances to possess a brown, and in others a gray colour. They frequently have ragged ends from which fibres project and wander into the ground-mass, where

* Geol. Mag., 1887, IV, (3), p. 65.

† Mr. J. C. H. Mingaye reports having discovered 47 grains of Al_2O_3 per gallon in a sample of mine-water from Peak Hill, analysed in the Laboratory of the Dept. of Mines. (Ann. Rept. Dept. Mines and Agric. for 1895 [1896], *in litt.*)

they gradually lose their identity. The characteristic lamination parallel to the orthopinacoid is exceedingly well developed. The base consists of fragments of diallage, which can frequently be seen becoming detached from the larger grains, more or less serpentinised bundles of fibres, and various alteration products. It would seem to be entirely composed of material brought into existence as the result of decomposition, and the rock at one time probably consisted solely of interlocking diallage grains.

Just as the serpentine has been derived from amphibole, so may the amphibole have been previously derived from pyroxene. This small boss of diallage rock may, in fact, be the sole survivor of a large mass of pyroxenic rock which was parent to all the Berthong amphibolites.

Prof. Bonney has described a somewhat similar diallage rock, which is associated with serpentines from the coast of Ayrshire in Scotland*. In a subsequent paper, however, he mentions it as containing a little olivine†.

Conclusion.—There would seem to have been three distinct periods of intrusion at Berthong; firstly we have the intrusion of the Silurian slates by granitite; secondly, the intrusion of both the slates and granitite by an ultra-basic rock; and lastly, the intrusion of the ultra-basic rocks by eurite.

The various rocks, after consolidation, would seem to have undergone great alterations. Granitic rocks have been crushed and rolled out into gneisses; amphibolites under the same influences have been changed into hornblende schists; while chemical agencies, which may or may not have accompanied the earth movements, have effected the complete serpentinisation of large masses of hornblende rock.

It is somewhat curious to notice the discrimination shown by the transforming agencies. Thus one will frequently find a hornblende rock with a perfect foliation, and yet the same rock but a few chains away will show no evidence of schistosity. Similar alternations of granite and gneiss can be observed, but the change is not generally so abrupt. Again, masses of amphibolite occur completely enclosed by serpentine.

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* Quart. Journ. Geol. Soc., 1878, XXXIV, p. 778.

† Geol. Mag., 1887, IV (3), p. 65.

V.—Notes on the Ashford Coal-field, County of Arrawatta: by E. F. PITTMAN, A.R.S.M., Government Geologist.

[Plates III and IV.]

DURING a recent trip to the North I stayed for two days at Fraser's Creek Station, and, through the courtesy of Mr. John Swan, was able to make an examination of the Ashford Coal-seam, and to trace and map the Coal Measures for some distance north and south of Coal Gully, where the coal was first discovered.

The Ashford Coal-seam was first examined and reported upon by Professor David (at that time a Geological Surveyor in the Department of Mines) in 1885,* and the same gentleman also briefly alluded to it (after a second visit to the locality) in his Presidential Address to the Linnean Society in 1893.†

The Ashford Coal-field possesses unusual interest, both from its mode of occurrence and from the fact that it is the most northerly extension of the coal-bearing rocks of Permo-Carboniferous age in New South Wales. It consists of a long narrow belt of conglomerates, shales, ironstone, and sandstone with a seam of coal about twenty-seven feet thick divided by a number of bands. Below the main body of the coal is a bed about two feet thick of brownish clay shales, with very numerous impressions of *Gangamopteris*, while in the sandstones above the coal *Glossopteris* also occurs. The palæontological evidence, therefore, taken in conjunction with the great thickness of the coal, leaves little doubt that these Coal Measures are identical with the Greta Group, the lowest as well as the most interesting of the Permo-Carboniferous Series.

The greatest width of the Ashford Coal Measures (measured horizontally across the strike) is only about three hundred and seventy yards, which, allowing for the dip, would give an actual thickness of the beds of only about two hundred and thirteen yards.

The measures have a general strike of about N. 30° E., and their dip is W. 30° N., at an angle of about 40°. They are bounded on the east by beds of dark bluish-gray and yellowish indurated claystones, which have a general strike of N. 20°—30° W., and dip E. 20°—30° N., at angles varying from 40° to 70°. These claystones were not observed to be fossiliferous; but they were traced by me without any break in their continuity from Southern Queensland, where they are regarded by Mr. Jack (Government Geologist of Queensland) as Gympie Beds, and they are apparently identical in their lithological characters and mode of occurrence with the Lower Carboniferous beds of the Vegetable Creek District

* Ann. Rept. Dept. Mines for 1885 [1886], p. 139.
† Procs. Linn. Soc. N.S. Wales, 1893, VIII (2), p. 586

referred by Professor David to the Gympie horizon.* It will be observed from the details given above, and from the sketch section accompanying this paper, that there is a very strongly marked unconformability between the Carboniferous or Gympie claystones and the Permo-Carboniferous Coal Measures which dip off them. This unconformability was previously alluded to by Professor David,† and is of special interest as bearing upon the view taken by the Geological Survey of New South Wales in referring these marine claystones to the Carboniferous Period. It appears difficult to reconcile such a marked stratigraphical unconformability, strengthened as it is by the palæontological break observable in other localities, with the classification of the Queensland Geological Survey, which includes the claystones (Gympie Beds) with the Permo-Carboniferous Series.

The Ashford Coal Measures are bounded on the west (along the greater part of their length) by a belt of intrusive granite, and this feature is of special interest, because the preponderance of the evidence appears to me to indicate that the intrusion occurred after the deposition of the Permo-Carboniferous Coal Measures.

The coal bears evidence of having been considerably altered. The lowest portion of the seam has a highly lustrous anthracitic appearance, and shows numerous polished or slickensided surfaces, which cause it to break up into small lenticular fragments several inches in length. Moreover, the upper portions of the seam present a dull semi-coked appearance, and, as will be seen by the analyses which are appended, have evidently lost a considerable proportion of their volatile hydrocarbons. The seam is inclined at a considerable angle, the dip being towards the granite in the only section in which it is visible.

It is not easy to account satisfactorily for the present position of the Coal Measures in relation to the granite. It appears probable, however, that they were originally deposited (in a denuded hollow) on the upturned edges of the Carboniferous (Gympie) claystones, and that there subsequently occurred an intrusion of granite, which caused foldings in the claystones and elevated some of the western portion of the Coal Measures (since removed by denudation), causing the western side of the remaining Coal Measures to sink, and thus assume the present inclination. It is, of course, possible that the intrusion of the granite may have occurred prior to the deposition of the Coal Measures, and that the inclined position of the latter may be due to a fault along the eastern side of the granite. This supposition, however, would not account for the alteration in the character of the coal, and I am, therefore, inclined to think that the former hypothesis is the more correct one.

The coal-seam is exposed in Coal Gully about two miles south of Fraser's Creek Homestead, but owing to the amount of weathering it has undergone it is impossible to get an accurate section showing the number of bands and the

* Procs. Linn. Soc., N. S. Wales, 1893, VIII (2), p. 587.
† *Loc. cit.*

thickness of clean coal between them. The following rough section of the measures was, however, taken by me, the measurements representing the true thickness of the beds :—

	ft.	in.
Roof—hard, fine-grained, grayish-white flaggy sandstone	2	7
Coal, with bands	27	0
Reddish-brown shales	0	8
Coal, with bands	1	3
Brownish clay-shales with numerous impressions of *Gangamopteris*	1	3
Carbonaceous shales, with thin seams of dirty coal and obscure plant impressions	15	6
Blue shales, with a band of nodular ironstone three feet from the base	18	2
Ferruginous conglomerate—the pebbles being formed of Carboniferous (Gympie) claystone	3	10
	70	3

Floor—Carboniferous (Gympie) claystones, lying unconformably.

It was impossible to obtain a section of the Measures further west than the roof of the coal-seam, because they were there covered by from six to eight feet thick of a horizontally-bedded gritty sandstone, which is probably of Tertiary age.

A shaft forty-one feet deep has recently been sunk in the coal-seam close by the spot where it outcrops in Coal Gully, and from this shaft about forty tons of coal have been extracted and used, chiefly in blacksmiths' forges about the district. With the aid of a borrowed rope I was enabled to descend the shaft, and obtained the following section of the coal at the bottom. Unfortunately there were no facilities for examining the coal at a greater height than six feet from the shaft bottom, and I am unable, therefore, to give any description of the quality of the coal nearer the roof of the seam, nor to record the thickness of clean coal between the bands :—

Section at bottom of shaft.	ft.	in.
(A) Hard coal, slightly coked	2	6
Shale band	0	2½
Hard coal, slightly coked	0	6
(B) Rather friable coal	0	6
Band	0	1
Splint coal	0	9
Shaly coal	1	6
(C) Splint coal	1	5
Coal and shales	0	9
(D) Slickensided anthracitic coal	1	9
Brownish clay shales—Floor of seam.	9	11½

Samples of the coal from A, B, C, and D were taken, and proximate analyses of these were subsequently made in the Geological Survey Laboratory by Mr. J. C. H. Mingaye, F.C.S., with the following results :—

Sample of slightly coked coal. (A)		
Specific gravity	1·328	
Hygroscopic moisture	·65	
Volatile hydrocarbons	22·15	
Fixed carbon	71·65	Coke, 77·20 %
Ash	5·55	
	100·00	

Sulphur in coal, ·480 %. Ash, light-gray in colour, granular. Coke, fairly well swollen, fine and lustrous. One pound of this coal will convert 13·53 lb. of water into steam.

Sample of rather friable coal. (B)

Specific gravity	1·342	
Hygroscopic moisture	·55	
Volatile hydrocarbons	24·65	
Fixed carbon	67·80	Coke, 74·80 %
Ash	7·00	
	100·00	

Sulphur in coal, ·357 %. Ash, light-gray in colour, granular. Coke, well swollen, fine and lustrous. One pound of this coal will convert 14·08 lb. of water into steam.

Sample of splint coal. (C)

Specific gravity	1·349	
Hygroscopic moisture	·75	
Volatile hydrocarbons	23·25	
Fixed carbon	68·90	Coke, 76 %
Ash	7·10	
	100·00	

Sulphur in coal, ·357 %. Ash, light-gray in colour, granular. Coke, well swollen, hard and lustrous. One pound of this coal will convert 13·86 lb. of water into steam.

Sample of slickensided anthracitic coal. (D)

Specific gravity	1·374	
Hygroscopic moisture	·90	
Volatile hydrocarbons	21·55	
Fixed carbon	67·50	Coke, 77·55 %
Ash	10·05	
	100·00	

Sulphur in coal, ·453 %. Ash, light-gray in colour, granular. Coke, fairly well swollen, hard and lustrous. One pound of this coal will convert 13·86 lb. of water into steam.

It will be seen by the above analyses that the coal from the Ashford Seam is likely to prove an excellent fuel for steam or smelting purposes, and that in regard to calorific value, and percentage of ash, it compares favourably with many of the best coals of the Colony.

About one mile south of Coal Gully the Coal Measures were again seen in the bed of a small creek, and the following section was measured from west to east. The dip of the measures here is west at 35°. The coal-seam itself is not seen at the surface in this section:—

	feet.
Rather coarse bluish-gray conglomerates	206
Gray sandstone with *Glossopteris*	224
Concretionary ironstone	6
Strata covered by sand in creek-bed	51
Bluish-gray conglomerate with band (two feet) of concretionary ironstone	3½
Strata covered by sand in creek-bed	69
Coarse basal conglomerate	70½
Gympie claystones, dipping E. 2° N., at an angle of about 60°.	

About a mile and a half still further south some highly-indurated conglomerates and sandstones are visible in the bed of a small watercourse, and these appear to be the continuation of the Coal Measures, though the cause of the metamorphism is not apparent.

The country along the course of the Severn River is so covered by Pleistocene and recent deposits that it is a matter of much difficulty to define the limits of the Permo-Carboniferous rocks, which outcrop only in the beds of creeks or water-courses.

To the north of Coal Gully the first evidence of the coal occurs at a point close to Fraser's Creek Homestead. Here, after heavy floods, large masses of coal, weighing sometimes as much as a hundredweight, are found in the river, and there is every reason to believe, therefore, that the seam outcrops here in the bed of the Severn River. Unfortunately there is a long and deep waterhole covering the spot, so that it is impossible to fix it accurately.

A traverse of Myall Creek, which trends about due west, and enters the Severn River about a mile to the north of the spot just referred to, shows that Carboniferous (Gympie) claystones outcrop in every bend, for a distance of over two miles up the creek.

The geological formation underlying the reaches of the creek, between the bends, is hidden by deposits of sand, and it is of course possible that the narrow belt of Permo-Carboniferous Coal Measures may cross the creek under one of these reaches. It is hardly probable, however, that this could happen without some evidence of the presence of the Coal Measures being visible in such a deeply-cut dry creek, and I am inclined to think that the Coal Measures do not cross the creek, though there is evidence of their recurring further northward, near Bonshaw. The granite crosses the Severn River just at the junction of Myall Creek, and inclusions of Carboniferous (Gympie) claystones are here visible in the granite, pointing to the probability of the intervening Coal Measures having been entirely carried away by the intrusion at this point.

The road going in a westerly direction from Bonshaw towards Mendoc passes for about five miles over Carboniferous (Gympie) claystones. For a distance of about a mile very sandy soil is then met with, and a small outcrop of grayish gritty sandstone occurs on the eastern side of the sand belt; the road comes on to granite immediately after passing the sandy belt. I passed over this road some days before inspecting the Ashford Coal-seam, and while noting the occurrence of the sand belt and single outcrop of sandstone I had no idea that it was upon the strike of the Ashford seam. I think now, however, that there are strong reasons for believing that this sandy belt marks the extension northwards of the Permo-Carboniferous Coal Measures, especially as I was subsequently informed by Mr. Nicholls (who originally discovered the Ashford Seam) that there is an outcrop of coal showing in a small creek ten miles north of Fraser's Creek Homestead, and about one mile west of the Bonshaw Road.

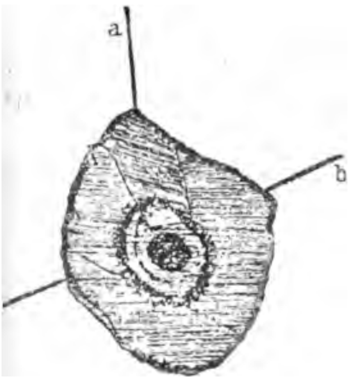
In conclusion, it may be remarked that the Ashford Coal-field, though limited in width, is of considerable importance on account of the excellent quality and thickness of the coal, as well as its distance from the nearest workable seam, and there is no reason to doubt that, with the advent of railways through this district, the deposit will become a valuable one.

VI.—Ottrelite-Phyllite from near Wattle Flat: by GEORGE W. CARD, A.R.S.M., F.G.S., Curator and Mineralogist.

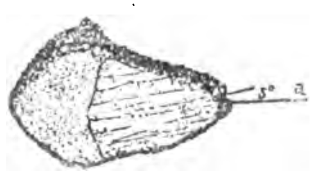
THIS note is based upon a brief examination of a small specimen described as coming from Bullock Flat, four and a half miles south-east from Wattle Flat, Sofala.

The rock is a blackish-green glossy phyllite. In every direction it shows the glistening faces of numerous detached lozenge-shaped plate-like crystals, having an average diameter of about a millimetre. The faces have a resinous to metallic lustre, are strongly curved, and are somewhat scaly. The plates cannot be satisfactorily detached from the rock, in which they lie without any definite orientation. They are affected by weathering to a much greater extent than the rock itself, becoming brown and earthy. The hardness of the mineral approximates to that of apatite; while the rock itself lies between two and three of Moh's Scale. The streak is practically colourless.

A microscopical examination of a very thin section [752] reveals this mineral in lozenge-shaped transparent grey crystals embedded in a fine-textured matrix of a pale buff colour. The crystals have sometimes an outline somewhat suggestive of a hexagon with the angles rounded off. The transparency of the crystals is interfered with by the presence of a multitude of dark specks and particles quite like those occurring in the base of the rock. The outline is very irregular, but is in most cases tolerably well defined. A dark border, of a width sometimes equal to one-sixth the length of a side, is always present. A concentric zoning, parallel to the outline, and consisting of dark bands merging into the mass of the crystal, is very common. The zoning is generally more marked towards the centre. In one instance there were indications of a diagonally-placed cross, as in chiastolite.



1.
Irregularly lozenge-shaped crystal; showing zoning and composite structure as seen between crossed nicols.
a....position of extinction in the small segment.
b.... do in the main crystal.



2.
Compound crystal, the individual on the right showing irregular cleavage.
a....position of extinction in the right-hand individual—inclined about 5° to the cleavage.

3.
Lozenge-shaped crystal showing dark margin and two directions of cleavage, to which one position of extention is inclined about 43° and 21° respectively; the angle of intersection being rather more than 60°. In the upper left-hand corner is a smaller individual (?).

Well-developed cleavage lines are present, but they have a tendency to pass into irregular cracks. Fig. 3 shows a crystal in which two sets of cracks intersect at an angle of rather less than 120°, while Fig. 2 shows only one set. Zoning and cleavage would not appear to occur together.

But little can be done with a quarter-inch objective towards the differentiation of the base of the rock; but the general similarity between it and the base of the crystals, as noticed before, is confirmed.

The slide being very thin, the crystals are quite colourless; but their potential pleochroism is abundantly indicated by the strong change from light to dark when the slide is rotated above the polariser.

The index of refraction is moderately high.

Between crossed nicols the ground-mass is seen to be crystalline throughout, polarising in shades of yellow, and having a streaky appearance. It can probably be regarded as consisting essentially of *sericite.* No colouration effects are afforded by the crystals beyond the change from light to dark already noted. The double refraction is therefore low. No satisfactory determination of optical sign could be made. Occasional indications of what may perhaps be twin-structure are brought out between crossed nicols. Fig. 1 illustrates the best instance of this. On rotating the stage the lozenge-shaped crystal is found to be compound in structure; a small segment, shown in the upper part of the figure by different shading, extinguishing in a different position to the remainder. One direction of extinction for the large and the small portions is indicated approximately by the lines *a* and *b* respectively. These directions are nearly at right angles to one another, so that there is, perhaps, but slight difference in the orientation of the two portions. It will be noticed that the zonal bands traverse the small segment, and that there seems to be a sort of overlapping of the different portions within the zone. In a sense the crystals shown in Figs. 2 and 3, may be regarded as compound, the cleavage cracks in each case occurring in one portion only. It would seem probable, however, that this structure is not due to true twinning, but to an actual mechanical change of position in the case of Fig. 1; while Figs. 2 and 3 may, perhaps, represent associated crystals. To sum up: the principal characters of the mineral—mode of occurrence and appearance, pleochroism, and cleavage—all seem to point towards a mineral of the *chloritoid* group, such as *ottrelite.* On the other hand the characteristic axis colours of that mineral have not been obtained, and the hardness is distinctly below that of typical ottrelite.

The deficiency in hardness may, perhaps, indicate that a large porportion of the substance of the crystal consists of included rock—a conclusion to which the similarity in microscopic appearance also seems to point—while the thinness of the section might account for the absence of colour.

It is evident that we have here a clayslate that has been converted into a phyllite by the development of minute crystalline structure, and in which crystals of what would appear to be a chloritoid mineral have been produced probably subsequent to the development of crystallisation. Adopting the nomenclature of Zirkel in the second edition of the "Lehrbuch der Petrographie," the mineral would appear to be *ottrelite* and the rock an *ottrelite-(sericite-) phyllite.*

It is much to be hoped that someone interested in the phenómena of contact metamorphism may trace this interesting rock to its home, and make an exhaustive examination of its characters.

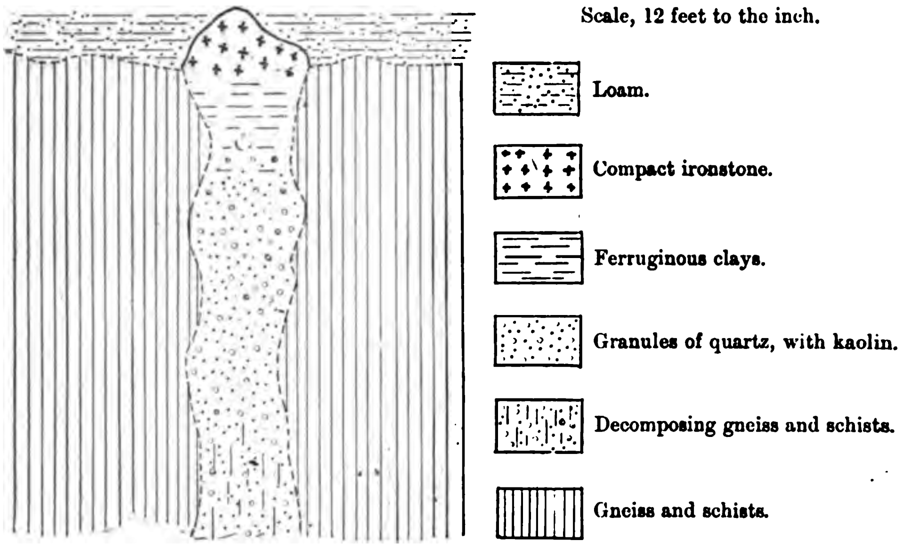
VII.—The Occurrence of Platinum in New South Wales: by J. B. JAQUET, A.R.S.M., F.G.S., Geological Surveyor.

GRAINS of platinum have not infrequently been met with in some of the auriferous drifts in the Colony. Prof. Liversidge mentions a nugget weighing two hundred and sixty-eight grains, as having been obtained from the bed of Wiseman's Creek, near Oberon.*

It is also found associated with gold and gemstones in the sea beaches between the Richmond and Clarence Rivers, and occasionally small parcels have been saved by miners working in these localities for gold.†

From a scientific point of view, perhaps the most interesting platiniferous deposits are those at Little Darling Creek, and Mulga Springs, near Broken Hill. Here the metal is found in ironstone, ferruginous claystones and decomposed gneiss. Samples assayed in the Department of Mines Laboratory by Mr. J. C. H. Mingaye yielded from traces up to 1 oz. 9 dwts. of platinum per ton.‡ Some of the samples contained small quantities of gold and silver, and the ironstone was generally more or less impregnated with carbonates of copper. No platinum could be seen in the ore, experiments made to determine the condition in which it is present have resulted in failure, while attempts at concentration have only been partially successful.§ During 1892 the Writer made an examination of the deposits in the field. The figure below which illustrates their general mode of occurrence is reproduced from his report.‖

* Minerals of New South Wales, p. 52.
† Records Geol. Survey N. S. Wales, IV, Pt. 1, p. 25; Ann. Rept Dept. Mines for 1878 [1879], p. 43; Procs. R. Soc. N. S. Wales, XXVI, p. 368; Ann. Rept. Dept. Mines and Agric. N. S. Wales for 1895 [1896], *in litt.*
‡ Ann. Rept. Dept. Mines for 1889 [1890], p. 249; Procs. R. Soc. N.S. Wales, XXVI, p. 371.
§ Ann. Rept. Dept. Mines and Agric. for 1891 [1892], p. 276.
‖ Ann. Rept. Dept. Mines and Agric. for 1892 [1893], p. 142.



Ideal Section of Platinum Deposit near Broken Hill.

Until the recent discovery of alluvial deposits in the vicinity of the newly surveyed townships of Fifield and Platina, there had been no production of platinum, upon a commercial scale, in New South Wales. These townships are situated about twenty-six miles north-east of Condobolin, and fifty-four miles north-west of Parkes, and are distant from one another one and a half miles.

During the last two decades it would appear that the country around Fifield has been intermittently prospected for alluvial gold, and a little platinum must from time to time have been obtained, though there is no record of this metal being discovered prior to 1887.

In this year Mr. J. F. Connolly, who received aid from the Government to prospect the district, reported having discovered alluvial platinum, and presented a sample to the Geological Museum. Nothing appears to have been done in the way of further developing the field until 1893, when Messrs. Fifield, Rand, and Party discovered rich alluvial gold near the site of the present township of Fifield.* Upon news of the discovery becoming known a rush set in to the district, and the lead which is now being worked was found soon afterwards.

The sedimentary formations represented are slates of Silurian (?) age, and fossiliferous sandstones and limestones of either Devonian or Siluro-Devonian age.

* Ann. Rept. Dept. for Mines and Agric. 1893 [1894], p. 63.

Mr. W. S. Dun, Assistant Palæontologist, has identified the following forms as occurring in specimens of the latter beds which I collected, and those which were given to me by Mr. C. J. Metcalfe, of Fifield:—

Limestone—
- Rhynchonella, sp. indet.
- „ allied to R. cuboides, *Sby.*
- Spirifera.
- Athyris.
- Cyclonema.
- Orthoceras.

Sandstones—
- Monticuliporoid corals, 2 genera.
- Rhynchonella, 2 species.
- Tentaculites.
- Pleurodictyum.

The Silurian slates are intruded by diorite. A thin section of this rock, which I examined under the microscope, consisted essentially of grains of hornblende and triclinic felspar with some accessory sphene and quartz.

Near Melrose Plains Homestead an auriferous reef has been discovered in the diorite, and a little exploratory work carried out upon it.

The "lead" or ancient water-course, which yields the gold and platinum-bearing drift, runs in a north and south direction for a little over a mile. It is from sixty to one hundred and fifty feet wide. The drift containing the precious metal is overlain by from sixty to seventy feet of loam with occasional bands of barren quartz drift. The platinum and gold occur in small, well water-worn grains, and are practically confined to the crevices in the bed-rock and the dirt within a few inches of the bottom. Occasional nuggets have been obtained which have weighed from a few grains up to 8 dwts.

The washdirt is first of all puddled in machines worked by horses. During this process the soft layer of bedrock which is broken down with the drift is pulverised and any metal which may be attached to it set free. The clean gravel is afterwards washed in ordinary sluice-boxes and the gold and platinum obtained. The gold is extracted by amalgamation with mercury and crude platinum left behind. The latter realises at the present time, upon the fields, twenty-four shillings per ounce. It contains about seventy-five per cent. of platinum, the balance being chiefly platinoid metals and iron.

An analysis by Mr. J. C. H. Mingaye, F.C.S., Analyst and Assayer to the Mines Department, gave as follows:—

Platinum	75·90	per cent.
Iridium	1·30	„
Rhodium	1·30	„
Palladium	traces.	
Osmiridium	9·30	„
Iron	10·15	„
Copper	·41	„
Gold	nil.	
Lead	traces.	
Siliceous matter	1·22	„
	99·48	

Value of Wash-dirt.

No. of Claim.	Loads washed.	Yield. Platinum. oz.	dwt.	gr.	Gold. oz.	dwt.	gr.	Ratio of platinum to gold in round numbers.	Value per load. £	s.	d.
4½ South	65	17	3	0	5	6	0	3 to 1	0	12	2
4½ ,,	16	5	9	12	1	11	22	3 ,, 1	0	15	8½
10 ,,	34	8	5	12	2	4	0	4 ,, 1	0	10	8
12 ,,	14	3	9	0	0	12	12	6 ,, 1	0	9	0
3 ,,	13	6	0	0	1	10	7	4 ,, 1	0	19	4
10 ,,	24	10	3	0	2	0	9	5 ,, 1	0	16	0
6 ,,	35	11	0	0	4	8	0	3 ,, 1	1	0	0
12 ,,	30	12	11	0	3	13	12	3 ,, 1	0	19	4
2 ,,	16	6	11	12	2	4	6	3 ,, 1	1	0	3
14½ ,,	2	1	2	6	0	6	6	4 ,, 1	1	4	6
9 ,,	2	0	16	6	0	5	2	3 ,, 1	0	19	3
3½ ,,	2	0	15	16	0	5	0	3 ,, 1	0	18	9
12½ ,,	2	1	12	9	0	9	21	3 ,, 1	1	17	10½
14½ ,,	6	3	8	12	0	13	12	5 ,, 1	1	2	1½
13 ,,	4	1	8	3	0	7	9	4 ,, 1	0	15	4
14 ,,	4	2	13	6	0	11	12	5 ,, 1	1	6	3

Mr. C. J. Metcalfe has kindly furnished me with the above returns obtained on treating parcels of dirt from various claims upon the lead.

It will be seen that the quantity of platinum per load varies from 5 to 12 dwts., and the quantity of gold from 1 to 3 dwts.; while the total value of the precious metals per load varies from 9s. to 37s.

Amongst the returns will be noticed several trial lots of two loads each from large dumps of dirt which have yet to be treated. These lots were in most instances, probably, picked samples, and have given a yield in excess of that which will be obtained from the dumps as a whole.

A somewhat curious specimen, which was given to me by a miner upon the field and is now in the Geological Survey Museum, (No. 6665)* deserves some notice here. It consists of a water-worn grain of platinum imbedded in a moderately hard, compact, white, amorphous substance. A qualitative analysis showed the matrix to consist essentially of a mixture of magnesium and calcium carbonates with a little insoluble aluminous material. The specimen was described to me as occurring *in situ* as a portion of a narrow lode in the bed-rock; but the waterworn character of the platinum grain would seem to preclude such an origin. In a shaft upon the field which had penetrated decomposing diorite to a depth of forty feet, I saw veins composed of a white material identical with the matrix of the specimen. It would seem to me that the metallic grain originally fell into a crack in the surface of the diorite and that the magnesian limestone was afterwards deposited around it.

* Registered number in Geological Survey Collection.

Only three well-authenticated instances of platinum occurring *in situ* would seem to be on record; at Sudbury, in Canada, it occurs chemically combined with arsenic *; at Broken Hill, as I have previously mentioned, distributed through ironstone and decomposed gneiss; and in Brazil in veins (?) associated with gold.† In Russia, where alluvial platinum deposits of enormous extent are to be found, the source of the metal has never been found and is still a matter for conjecture; so a considerable amount of scientific interest is attached to the genesis of platinum in all newly-discovered deposits.

In the vicinity of Fifield and Platina at an elevation of at least a hundred feet above the lead which is now being exploited outliers from a series of horizontally bedded conglomerates, or cemented drifts and shales, occur. The conglomerates are composed of rounded or subangular quartz-pebbles tightly cemented together by an infiltration of ferric oxide. The shales are highly ferruginous and much indurated.

In the absence of fossils I am unable to speak definitely as to the geological age of these beds; however, having regard to their general character and the amount of denudation that has taken place since their deposition, I am inclined to think that they are of Tertiary age, or even older.

Upon the top of Jack's Look-out, a low hill which is distant about two miles from Fifield in a south-easterly direction, a good section of the beds is to be seen. Here they have been found to contain water-worn grains of gold and platinum, and some prospecting work has been carried out upon them. As is generally the case with widely distributed auriferous drifts the precious metals occurred in patches and not in defined "runs." This fact and the great expense of treating the hard cement discouraged the miners, and all work has now been abandoned in this locality.

I obtained from the Fifield-Platina lead boulders of cement, which were indistinguishable lithologically from portions of the beds upon Jack's Look-out; and I am of opinion that the precious metals in the lead were originally contained in those portions of the conglomerate and shale beds which have been denuded away; I am suggesting, in fact, that the older beds with their scattered patches of platinum and gold have been disintegrated and ground-sluiced by nature, and that the deposits now being worked represent the resultant concentrates. If we admit this hypothesis then the ultimate source of the metals is still an open question. It is possible that the components of the Tertiary (?) beds may have been derived from a source far removed from Fifield.

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* Am. Jour. Eng. Sci., 1889, XXXIX., p. 67. (*Fide* Mineral Industry, 1893, I, p. 376.)

† Geol. and Phys. Geog. of Brazil, Prof. Hartt. (*Fide* Mineral Industry 1893, I, p. 376.)

It was suggested to me that the platinum might have been derived from a reef or reefs in the vicinity of the field. A consideration of the general mode of occurrence of platinum would perhaps cause one to discredit such a theory, and the ascertained facts seem to me to disprove it altogether. The dividing line of the Bogan and the Lachlan River watersheds passes through Fifield, and the platinum deposits have been followed up one side of the ridge and down the other. So one or more of the supposititious reefs should be located upon the highest ground; yet, notwithstanding all the sinking and driving that has been carried out, no reefs had been found. Moreover, the grains of metal appear to be uniformly waterworn.

Dry seasons have prevailed since the discovery of the field, and its development has been much retarded in consequence. The washing of dirt has sometimes been completely suspended for many months at a time on account of the shortage of water. At the present time 7,000 loads of washdirt are dumped around the various shafts awaiting treatment.

About 1,200 oz. of crude platinum have already been sent away from this field, and, including the deposits in the immediate vicinity of Fifield and outside the Fifield-Platina Lead proper, the gold won has totalled about 1,800 oz.

A few of the parties have already worked out all the "pay-dirt" from their claims, while others have a year or eighteen months' work in sight.

A consideration of the circumstances connected with the origin of the platinum and the fact that it has been found in small quantities over a wide area of country has made me of opinion that other platiniferous leads are to be found in places under the flats in the district. Prospecting for such leads, however, would be a very tedious operation, since the flats are for the most part of great extent, and there is nothing upon the surface to indicate the path of the gutters below.

Small quantities of drift yielding a payable quantity of platinum associated with gold and tin (cassiterite) have been mined about ten miles north-east of Fifield, near the village of Burra Burra.

Though no very rich ground has been found at Fifield, yet employment has been found for from 150 to 200 men at a time when a field for their labour was sorely needed. Moreover, with the opening up of the field a new industry has been created, and an addition made to the long and varied list of mineral products exported from New South Wales.

VIII.—The Occurrence of Copper at the Dottswood Mine, Queensland: by GEORGE W. CARD, A.R.S.M., F.G.S., Curator and Mineralogist.

[Plate V.]

THIS property is situated south-east from Keelbottom Creek, fifty miles from Townsville. Having lately had an opportunity of examining a few rock specimens and cores, the Writer considers that the occurrence of copper there is sufficiently interesting to justify a reference to it in these Records. The specimens, together with particulars of their position in the bores, were obtained from Mr. W. S. Head. A plan and section taken from the Prospectus of the Company will be found on Plate V. By reference to this plate it will be seen that the copper deposit has been reached by shafts and bores for a distance of four hundred feet from the outcrop; the dip being very low at first, and then increasing to about 45°. Overlying the bed in which the rich copper ore occurs there is, in every case, a reddish pseudo-amygdaloidal rock [755], which is also stated to constitute the surface rock of the district. A little native copper is said to have been found in this.

In every instance after this has been passed through it is succeeded by a compact black rock containing copper [634, 756], and it is at the base of this bed that the ore-body has, up to the present, been invariably met with. The total thickness is said to be about five feet, while the ore-body varies up to eighteen inches. The ore would seem to consist principally of native copper with siliceous and calcareous gangue; but oxidised ores are also said to occur. Wherever the ore-body has been passed through, it is succeeded by a grey spotted rock [759], and in this the occurrence of copper has not yet been recorded. A bore has been driven fifty feet into this grey rock. Some twenty years ago this property was inspected by Messrs. Norman Taylor, W. S. Phillips, and Thos. Symons. The former gentleman describes (in a report to the Company) the hanging-wall as consisting of "altered and very hard cherty and epidotic rock," and the "lode" as resting on a "dyke of amygdaloidal trap." He also refers to having observed "slickensides" in some specimens of ore. Mr. Symons refers to another lode about half a mile from the other workings. At a depth of fifteen feet "the lode opened out to about two feet; this lode showed a good sample of stone, bearing oxide and copper, and runs nearly east and west, with an underlay of about three feet in six." An examination of the specimens revealed the following features:—

[755.] A reddish pseudo-amygdaloidal rock. A multitude of lath-shaped felspar microlites are thickly set with calcite and ferrite in a dusty base. A marked

fluidal structure is noticeable. The amygdaloidal structure results from the replacement of the original rock substance rather than from an infilling of vesicular cavities. This rock is described as overlying the cupriferous bed, and is said to sometimes contain copper.

[634, 756.] From different depths in different bores. One specimen itself contains native copper, while the other is described as coming from just above the ore-body. They are identical in character, consisting of lath-shaped felspar microlites closely crowded in a fluidal manner with chlorite, viridite, and ferrite. The alteration products (chlorite, &c.) appear to result from the replacement of felspars and interstitial matter. The rock is traversed by secondary veins, and contains secondary quartz in considerable quantity.

[757, 758.] These were detached (by the Writer) from a lump of the ore-body rich in native copper. [758] is identical with [634] and [756], except that it is veined, and in part replaced by quartz, calcite, and iron-oxide. [757] is a mass of quartz and calcite.

[759.] A grey pseudo-amygdaloidal rock underlying the ore-body, and not known to be cupriferous. Tabular felspars—some porphyritic—are closely crowded, with chlorite, viridite, and ferrite.

Thus only two varieties are present. [755–8, 654] represent a mass of rock characterised by lath-shaped microlites of felspar arranged fluidally; this mass comprises the ore-body. [759] is characterised by tabular felspar—porphyritic crystals and microlites.

No augite or olivine has been recognised in any of the rocks. There is a close resemblance between them and the "*diabase-porphyrite*" described by Iddings from the Lake Superior Copper Mines. It may be convenient to refer to them as *melaphyres* in the field, but in all probability on further study they will be found to be altered *andesites*, the *porphyrites* of some English petrologists. Messrs. Etheridge and Jack refer incidentally * to cupriferous old lava beds, consisting of porphyrite, at Keelbottom Creek, and to these the rocks now being examined doubtless belong.

Two important deductions can be drawn from these results :—

1. If the sample of ore examined be really characteristic, then there is no true lode present, and it is somewhat surprising that slickensides should have been observed. The specimen was an integral portion of the porphyrite traversed by veins of, and to a certain extent replaced by, calcite, chlorite, ferrite, &c., and containing native copper.

* Geology of Queensland, Brisbane, 1892, p. 133.

2. The uniform character of the overlying rock, and its structure, the flatness of the surface, and the low angle of dip, all point to a lava flow rather than a dyke. It seems most probable that the underlying rock is of the same nature.

There would thus appear to be a series of bedded flows of porphyrite, the copper occurring more or less scattered through the upper bed, and concentrated with a siliceous and calcareous gangue as an ore-body in the upper bed just at its contact with the next.

There is an analogy between the occurrence of copper here and at Lake Superior, where the metal is found replacing, and filling up interstices in, interbedded conglomerates and various basic volcanic rocks, some of which closely resemble the Dottswood porphyrites. These have proved cupriferous for more than five thousand feet, but not continuously. At Walli, a few miles north of Woodstock, in New South Wales, there is a similar occurrence.

In the event of copper-mining being pursued in this district, it would be very desirable to prove the presence or absence of copper in succeeding strata by deep bores.

PLATE I.

Platyceras (Orthonychia) altum, *Dana?*

Fig. 1. A complete specimen, lateral view, showing the general curvature of the shell, over-hanging apex, concentric laminæ, and radiating striæ. Harper's Hill.

Fig. 2. A second specimen rather more curved, in which the radiating striæ are less distinct. Harper's Hill.

Platyceras (Orthonychia) cornu-capella, *Eth. fil.*

Fig. 3. Lateral view of the shell, minus the apex, with gradate concentric ridges, and remains of faint radiating striæ. Harper's Hill.

Platyceras (Orthonychia) ungula, *Eth. fil.*

Fig. 4. Lateral view of the short conical shell, with irregular concentric ridges. Harper's Hill.

Euomphalus cera, *Eth. fil.*

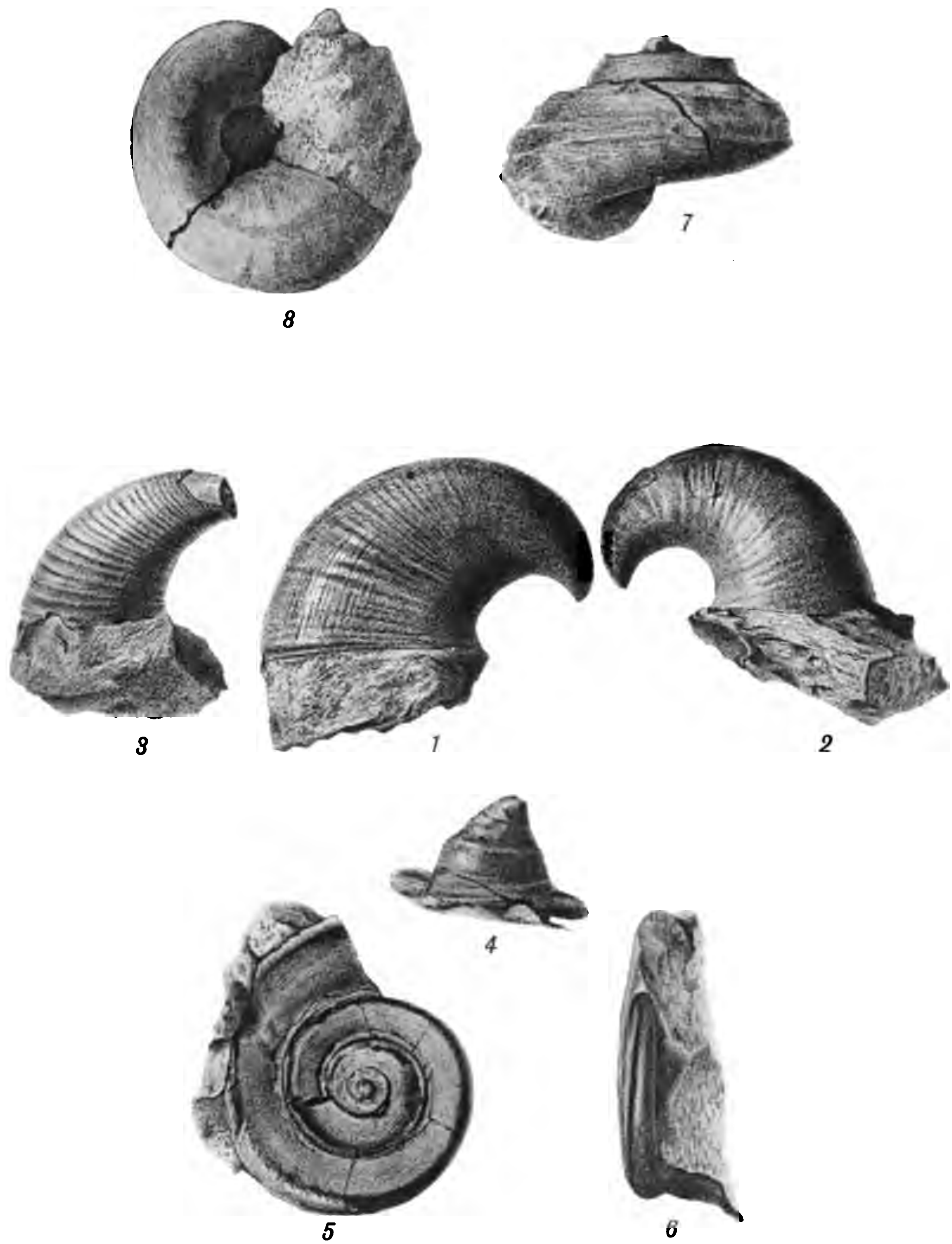
Fig. 5. Upper or apical view exhibiting the depressed whorls, and obtuse keel around the edge of the body whorl. Dungog-Paterson Road.

Fig. 6. Side view of the same specimen, showing the discoidal wafer-like outline.

Mourlonia? Waterhousei, *Eth. fil.*

Fig. 7. Side view, with the depressed turreted whorls; the upper straight-walled, the body whorl with its three carinæ. West Maitland.

Fig. 8. Basal view of the same specimen, with the deep umbilicus.



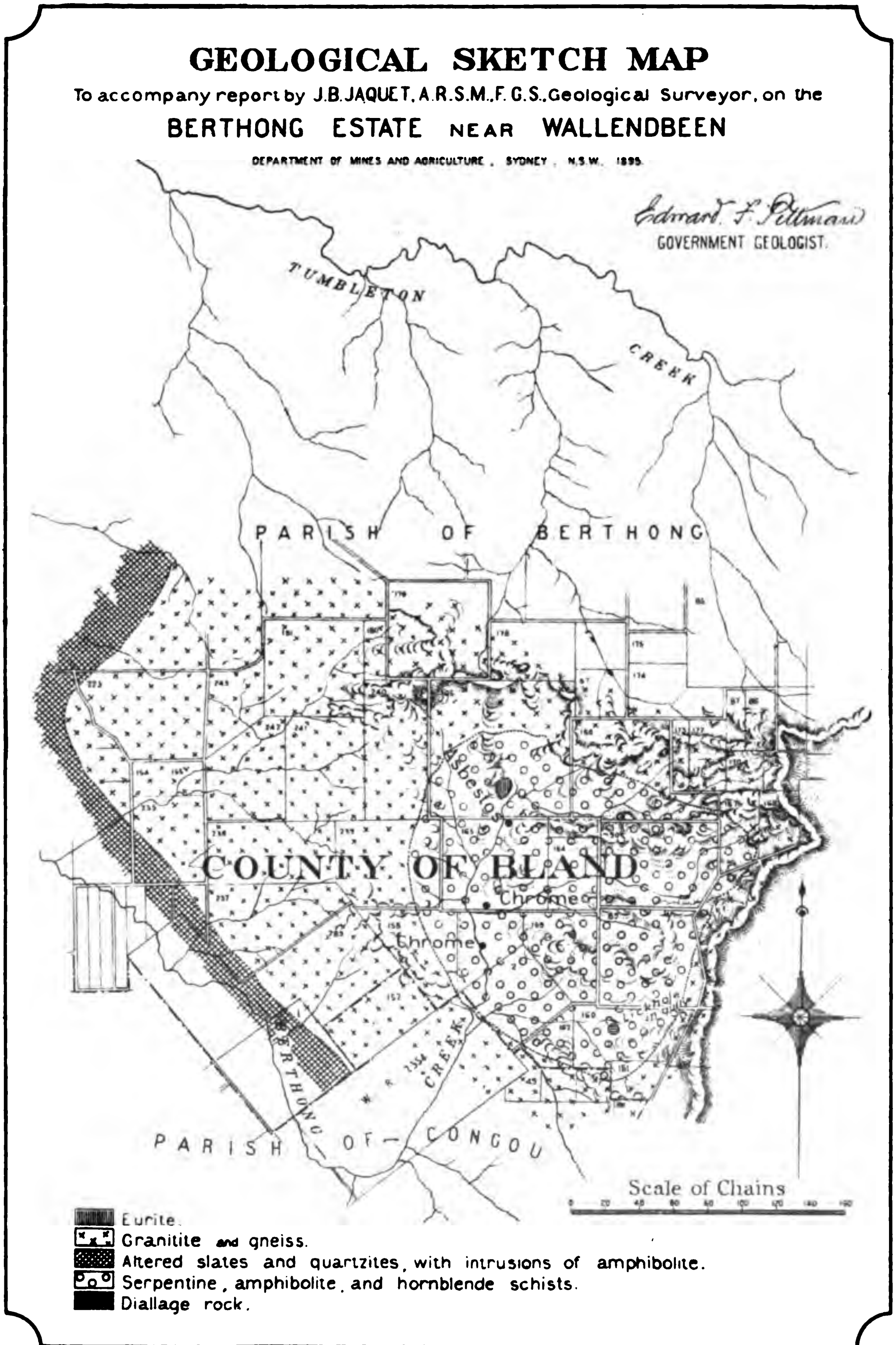
P. T. Hammond, del.

Heliotype.

PLATE II.

Geological sketch map of the Berthong District, Co. Bland—showing the mode of occurrence of the Intrusive and Metamorphic rocks.

Scale—100 chains to 1 inch.



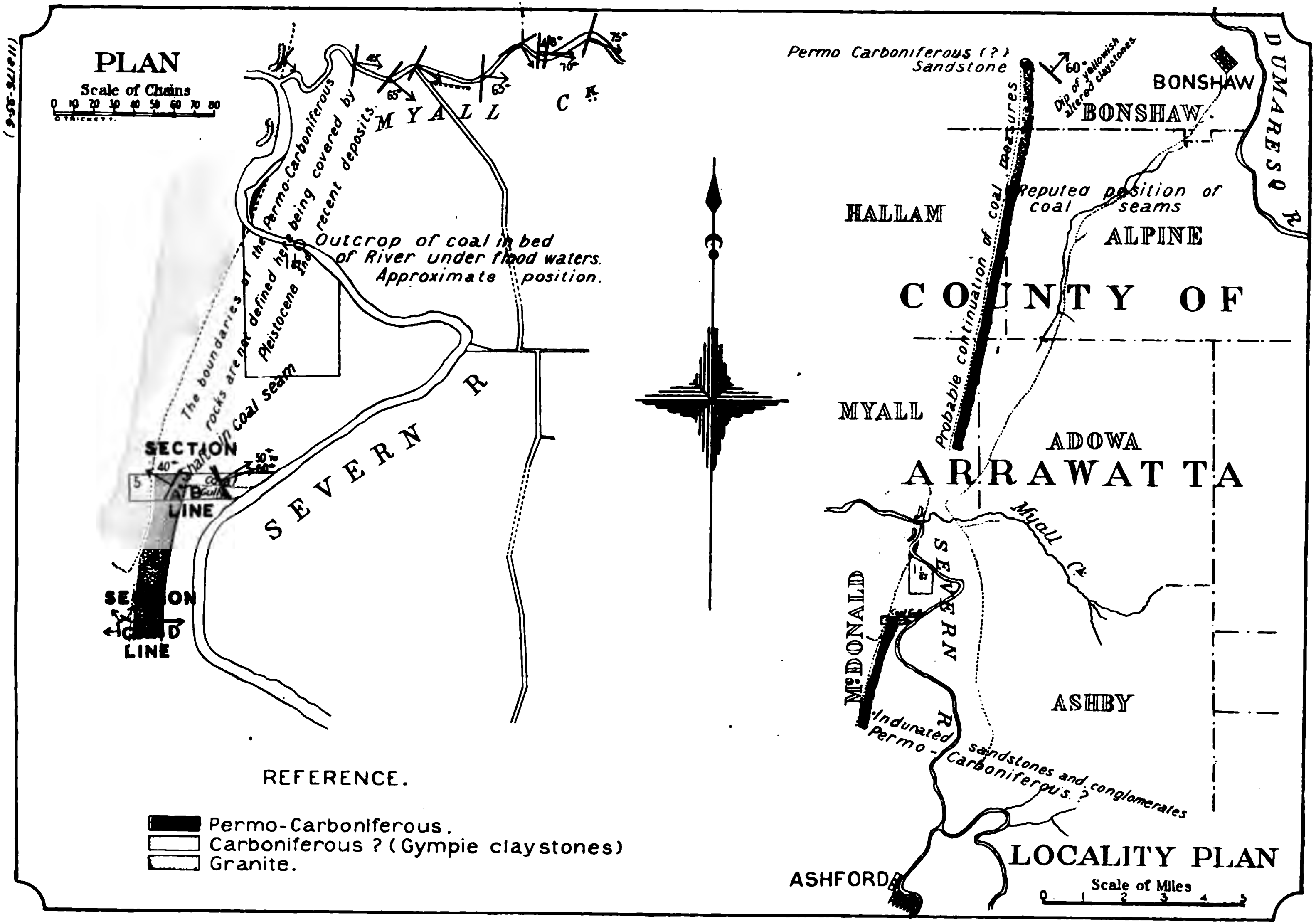
(11 a 176-98-6)

PHOTO-LITHOGRAPHED AT THE GOVT. PRINTING OFFICE,
SYDNEY, NEW SOUTH WALES.

PLATE III.

Geological sketch map of the Ashford Coal Measures.

Scale—80 chains to 1 inch.



REFERENCE.

Permo-Carboniferous.
Carboniferous ? (Gympie claystones)
Granite.

(11a176-93-6)

PHOTO-LITHOGRAPHED AT THE GOVT. PRINTING OFFICE, SYDNEY, NEW SOUTH WALES.

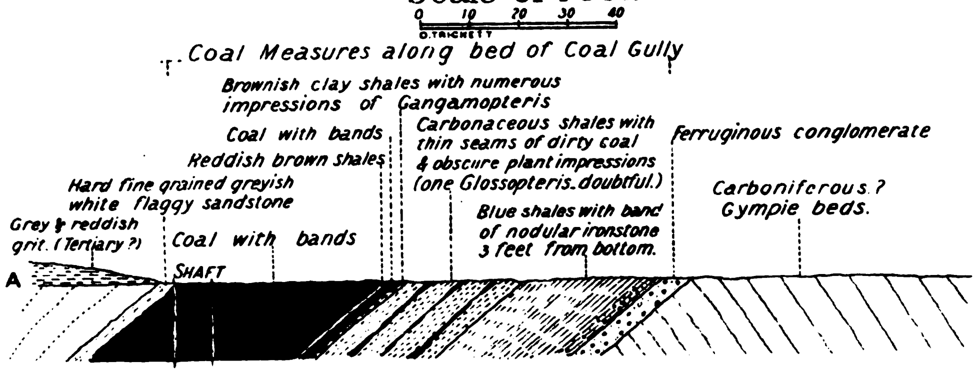
PLATE IV.

Sections to accompany the Geological sketch map of the Ashford Coal Measures.

Scales on Plate.

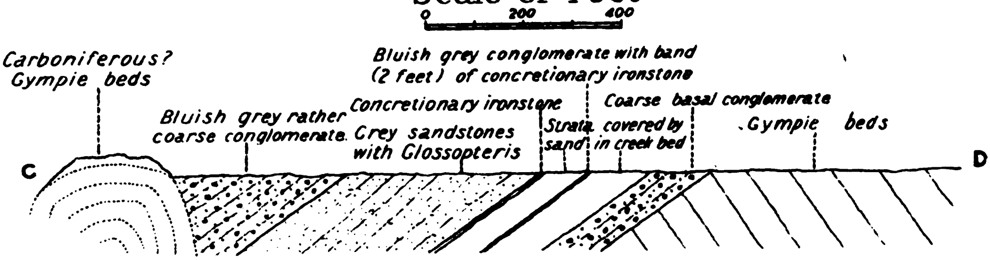
SECTION ON LINE A B

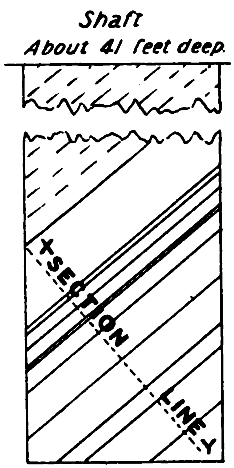
Scale of Feet.



SECTION ON LINE C D

Scale of Feet





SECTION ON LINE X Y

Scale of Feet

	FT	IN	
X	2	6	Hard coal slightly coked.
	0	2½	Shale band.
	0	6	Hard coal slightly coked.
	0	6	Rather friable coal.
	0	1	Band.
	0	9	Splint coal.
	1	6	Shaly coal.
	1	5	Splint coal.
	0	9	Coal and shale.
	1	9	Slickensided anthracitic coal.
Y			Brownish clay shales.

(11a 176-95-6.)

PHOTO-LITHOGRAPHED AT THE GOVT. PRINTING OFFICE, SYDNEY, NEW SOUTH WALES.

PLATE V.

Sketch Plan and section of the Dottswood Copper Mine, Queensland.

Scale—200 feet to 1 inch.

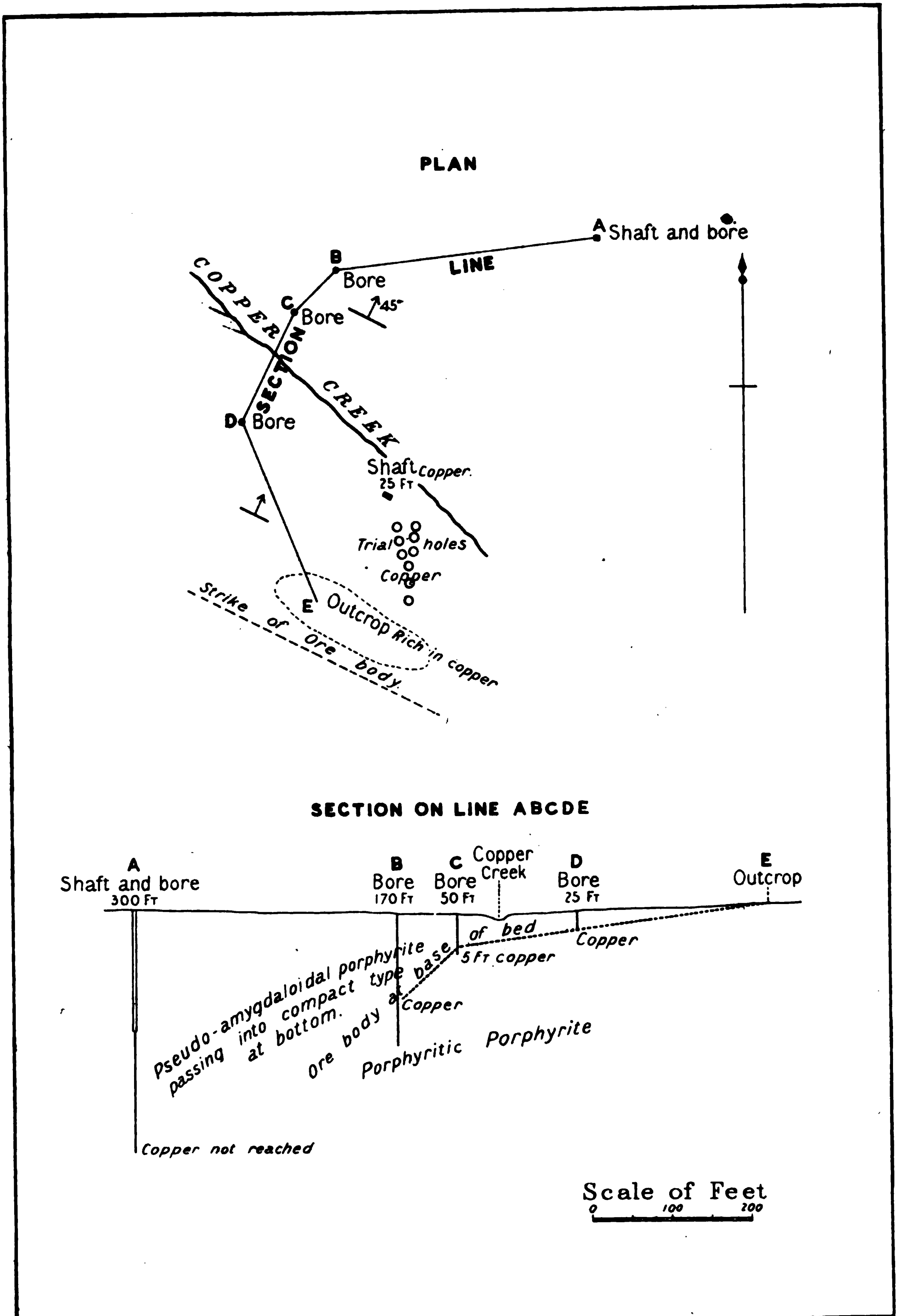


PHOTO-LITHOGRAPHED AT THE GOVT. PRINTING OFFICE, SYDNEY, NEW SOUTH WALES.

DEPARTMENT OF MINES AND AGRICULTURE, SYDNEY.

RECORDS

OF THE

GEOLOGICAL SURVEY OF NEW SOUTH WALES.

Vol. V.] January, 1897. [Part 2.

CORRIGENDA.

Vol. V, Part I, p. 35, line 22. For *Mr. J. C. H. Mingaye, F.C.S.*, read *Mr. H. P. White, F.C.S., Assistant.*

A. H. Foord, when describing Carboniferous fossils from West Australia, met with evidence that produced in his mind a contrary opinion, for amongst species recorded by him occurs *Syringothyris exsuperans*, De Kon. sp., apparently determined from fragmentary dental plates, in the first instance, that were found to piece together,† and subsequently portions of the ventral valve displaying characteristic features.

The valves of *Spirifera exsuperans* externally present all the characters of *Syringothyris*. The shell is subpyramidal, transversely elongate, both valves possessing acute and extended cardinal alations or extremities. The ventral or peduncle valve is very long (*i.e.*, from the umbo to the front), with a shallow wide sinus, much produced forwards. The umbo is high, feebly curved, pointed, channelled, and only overhanging the cardinal area at its extreme apex. The cardinal area is high, large, and extends the whole length of the valve, longitudinally striate, and with a large triangular fissure or delthyrium, which is partially closed by an arched deltarium. The exterior is ornamented by a large number of usually simple rounded radiating costæ, except in the sinus, which appears to be destitute of

* Foss. Pal. Nouv. Galles du Sud, 1877, Pt. 3, p. 249.
† Geol. Mag., 1890, VII (3), pp. 149, 153.

them. The costæ are separated by narrow shallow inter-costal spaces, whilst imbricating laminæ or strong lines of growth probably existed, although they are only now faintly visible in the specimens before me.

The dorsal or brachial valve is much less convex than the ventral, with a depressed rounded fold; its umbo also depressed, and inconspicuous; the fold without costæ, but a median longitudinal groove, the outward evidence of the median septum.

De Koninck's description is at first difficult of comprehension. In the first place he does not describe the ventral valve by name, but speaks of the dorsal as possessing a "lobe médian simple," that can be no other than the fold. He adds "crochet très élevé," "area très grand"; "un petit pseudodeltidium." These characters are those of parts of the ventral valve, not the dorsal. Now, although all the foregoing points are correct in themselves as specific features of the shell, it appears to me that the Author in framing his description has commenced with the characters of the ventral and leaped to those of the dorsal valve, without diffentiating between them. There can be no other reading, for the "lobe médian simple" settles the matter. I refer to this, because it must be exceedingly puzzling to the ordinary reader, and has a strong bearing on what I have to say later on.

De Koninck describes the internal structure of the ventral valve as follows:—Two strong diverging dental plates occupy the interior of the ventral valve, of which the frame-work is perfectly consolidated. Between these plates, which do not extend for more than half the depth of the valve, and immediately below their junction is visible the central adductor, impressioned in the form of a lozenge (rhomboidal), longitudinally grooved, and flanked by two very deep cardinal impressions striated lengthwise. The remainder of the interior of the valve exhibits irregular oblique grooves, probably dependant on the vascular markings.

All of the specimens of this shell that have come under my notice, with the exception of two, are from the Carboniferous rocks of New South Wales, the exceptions being from beds of similar age in West Australia. We may now proceed to a consideration of the specimens figured in Pl. VI.

Fig. 1 is the most complete example in the Mining and Geological Museum from a N. S. Wales locality that has so far been collected. It represents the cardinal area of a ventral or peduncle valve, delthyrium, and slightly incurved and channelled umbo, with a fairly well preserved dorsal valve in apposition. In this example some portion of the testaceous matter is retained on the ventral valve, but not on the dorsal, except here and there as a thin pellicle. The upper third of the delthyrium is infilled with a slight shelly plate, on a level with the general surface of the area, broken at its lower extremity, but this is not represented in the drawing. This is probably the remains of a deltarium. Each edge of the delthyrium is bordered by a rounded raised rim or beading, and on its inner side the

delthyrial grooves. The umbo is also seen to be channelled by the sinus quite to its apex, and faint traces of transverse striation are also visible on the area. The very close general resemblance borne by this specimen to other species of *Syringothyris* is apparent.

In the dorsal valve the low broad fold is seen to be devoid of costæ, but exhibits the impression of the septum and the simple costæ on the lateral slopes are visible.

Fig. 2 represents a specimen somewhat similar to Fig. 1, but the whole of the testaceous matter is removed from the area except on one side. This removal enables the position of the dental plates as diverging slits to be seen. Towards the apical portion of the fissure is the cast of what Prof. W. King termed the "arch," or commencement of the dental plates;* Dr. Thomas Davidson, the "transverse plate;"† and Messrs. Hall and Clarke, the "transverse rostral plate."‡ The dorsal valve attached to this specimen exhibits characters similar to those of Fig. 1, except that there are faint indications of costæ on the fold.

A crushed specimen devoid of testaceous matter is depicted in Fig. 3, generally similar to Fig. 2, except that, possibly in consequence of the distortion it has undergone, the "arched," or "transverse plate" is much wider. Again the apical portion of the ventral sinus is visible as a groove on the cast of its umbo, the impression of the dorsal septum on the fold, and the costæ on the lateral slopes. The slits left by the decomposition of the dental plates are wide and deep. This figure corresponds remarkably well with one of Messrs. Hall and Clarke's of the cardinal view of an internal cast of *Syringothyris Randelli*, Simpson.

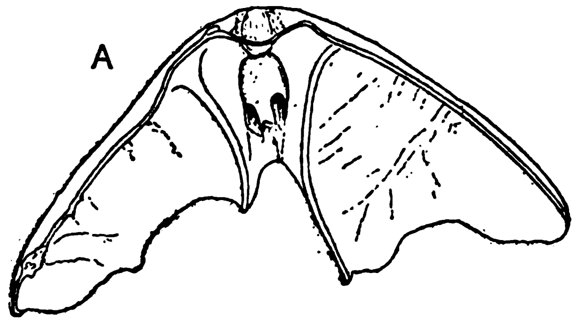
Figs. 5 and 6 are views of one and the same specimen, and as they exhibit similar features to those already described in other specimens need not be further referred to.

The myology of *Spirifera exsuperans* is only known from the imperfect specimen, Fig. 4, the ventral view of an internal cast. The muscular impressions occupy a similar area circumscribed by the dental plates, here represented by slits, as in *Spirifera* and *Syringothyris*, but the drawing does not do justice to the structure as preserved. The small double adductor impressions are faintly visible, separated by the short ventral septum, here a groove, and more apparent towards its forward portion. The cardinal or diductor impressions, one on either side of the adductors, are more plainly visible as oval impressions radiately ridged. A comparison may be made with one of the excellent figures of Messrs. Hall and Clarke, in this instance again to that of *Syringothyris Randelli*, Simpson,§ and to some extent to one of Prof. King's also.||

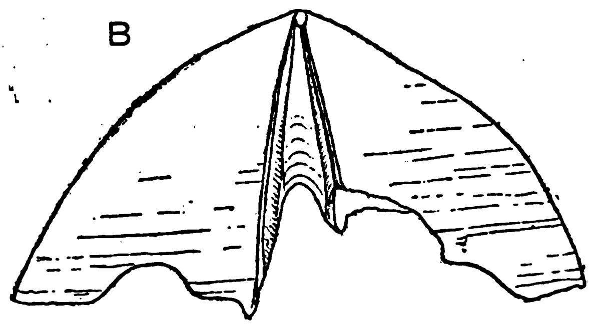
* Ann. Mag. Nat. Hist., 1868, II (4), p. 16, t. 2, f. 11.
† Geol. Mag., 1867, IV, pp. 312, 315, t. 14, f. 7-9.
‡ 13th Ann. Report State Geol. N. York for 1893 (1894), II, t. 30, f. 4.
§ 13th Report *loc. cit.*, t. 30, f. 6.
|| Ann. Mag. Nat. Hist., *loc. cit.*, t. 3, f. 31.

The foregoing appears to be all the information that can be gained from the New South Wales specimens of *Spirifera exsuperans*, and we may now turn our attention to two from the Carboniferous rocks of West Australia :—

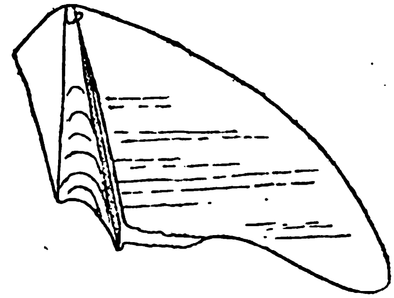
A



B



C



Both these essentially bear out the structure of those from New South Wales, but also have the advantage of possessing the whole of the testaceous matter, so far as the shells are preserved.

Fig. B. has the same wide, high, and transversely-striated ventral area, and open delthyrium floored by the transverse plate with its excavated lower margin as in the previously described specimens from New South Wales; also the delthyrial grooves and thickened margins are plainly visible. The transverse plate in this specimen is particularly well-developed. It is not to be mistaken for the deltarium, which in perfect examples either arches over the delthyrium, as seen in one of Prof. King's excellent illustrations,* and illustrated by Hall and Clarke in *Syringothris Randelli*, Simpson,† as well as in the only Australian specimen in which this structure has been observed‡; or, is apparently composed of two halves, being thus figured by Davidson in *Syringothyris distans*§. The arched deltarium does not necessarily entirely close the delthyrium, but leaves a semi-circular opening within a short distance of the umbo of the dorsal valve, as illustrated by Prof. King||, and described by Schuchert in *Syringothyris alta*, Hall¶. The present specimen also exhibits on one side the transverse plate, the line of separation between it and the contiguous dental plate as a rather wide groove, extending almost to the excavated lower end.

The second specimen (Fig. C) from West Australia is only one-half the ventral area, being broken off short at one of the dental plates, exposing a lateral view of this structure descending into the valve, the line of separation having taken place along the groove previously described at the side of the transverse plate in Fig. B.

The first figure (Fig. A) represents the interior of Fig. B, and is an instructive one. The dental plates are worn down, although the bases are still visible. A mass of testaceous matter fills the umbonal cavity, rendering it very solid. In the centre of this is a somewhat pyriform depression, occupied by a slight prominence, tailing off below into a narrow projection, leaving on either side an elongated slit. The surface of the lateral internal portions of the area outside the dental plates bear numerous vascular markings.

In a typical *Syringothyris*, from the lateral margins of the transverse plate, on its inner side, shelly processes or plates are given off, and curling towards one another, are partially united in the middle line forming an imperfect tube termed the syrinx, and first observed in these shells by Professor N. H. Winchell. By Messrs. Hall and Clarke this is regarded as the receptacle of the atrophied pedicle.** There are numerous good illustrations of this tube, for instance, in *Syringothyris distans*, Sby., by Davidson††; in *S. typa*, Winchell, by the same author‡‡, and Hall

* Ann. Mag. Nat. Hist., *loc. cit.*, t. 2, f. 1.
† 13th Ann. Report State Geol. N. York, *loc. cit.*, t. 30, f. 11.
‡ Foss. Pal. Nouv.-Galles du Sud, Pt. 3, 1877, t. 15, f. 1.
§ Geol. Mag., 1867, IV, t. 14, f. 7 and 9.
|| Ann. Mag. Nat. Hist., *loc. cit.*, t. 2, f. 1.
¶ 43rd Ann. Rept. N. York State Mus. for 1889 (1890), p. 237.
** 45th Ann. Report N. York State Mus. for 1891 (1892), p. 483
†† Geol. Mag., 1867, IV, t. 14, f. 6-9.
‡‡ *Ibid*, f. 4.

and Clarke*; in *S. subcuspidata*, Hall, again by Hall and Clarke†, and also in *S. texta*, Hall, by the same‡. It is possible that the downward projection in the pyriform depression of Fig. A, may represent this syrinx either in a still more atrophied, or even undeveloped state.

The result of my investigation of the structure of *Spirifera exsuperans* seems to show that it agrees with *Syringothyris* in most of its characters, departing from that type only in the more trivial. Even admitting that the projection from the pyriform depression on the underside of the transverse plate is not the remains of a syrinx, this will not wholly invalidate the reference to *Syringothyris*, since Mr. C. Schuchert has described§ at least one species (*S. Herricki*) in which this tube was not present. In this case both *Spirifera exsuperans* and *Syringothyris Herricki* will be more in accord with certain species of American *Spirifera*, such as *S. plenus*, Hall, which is said to have the shell structure of *Syringothyris*, and a well-developed transverse plate without a syrinx.

The reference of De Koninck's species to *Syringothyris* is still further borne out by the punctate and at the same time peculiarly fibrous structure of the shell. The punctæ (Pl. VI, Fig. 7) are distinctly visible on the lateral slopes of another specimen not otherwise figured. No trace of the perforations is to be seen on any of the ventral areas.

Localities:—Greenhills, nine miles north-east of Paterson, County of Durham, N. S. Wales (*C. Cullen*); Shelly ridge, twenty miles west of Tamworth, County of Parry, N. S. Wales (*C. T. Musson*); Nolan's 640 acres Selection, Parish of St Aubyn, County of Durham, N. S. Wales; Carboniferous.

Gascoyne River, W. Australia (*H. P. Woodward*); Carboniferous. Mr. A. H. Foord also records *Syringothyris exsuperans* from both the Gascoyne and Irwin Rivers in West Australia‖.

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* 13th Ann. Report State Geol. N. York, *loc. cit.*, t. 30, f. 15.
† *Ibid*, f. 3.
‡ *Ibid*, f. 5.
§ 43rd Ann. Report N. York State Mus., *loc. cit.*, p. 233.
‖ Geol. Mag., 1890, VII (3), pp. 149, 153.

X.—On the Occurrence and Classification of some New South Wales Meteorites, by GEORGE W. CARD, A.R.S.M., F.G.S., Curator and Mineralogist.

[Plates VII & VIII.]

THERE are in the Mining and Geological Museum, Sydney, the Cowra, Bingera, and a very small portion of the Moonbi meteorites, together with a fragment from Temora. Of these, the Bingera iron was described by Prof. A. Liversidge, F.R.S., in a paper read before the Royal Society of New South Wales in December, 1880, and subsequently reprinted*; while in 1893 Mr. J. C. H. Mingaye, F.C.S., communicated a note on the Moonbi iron to the same Society.†

Until the appearance of the latest "Catalogue of the Collection of Meteorites in the British Museum, London," in 1894, the occurrence of the Cowra meteorite does appear to have been recorded. It will not be possible to refer to this catalogue again in this note, as no copy of it appears to be available in any Sydney library. As far as I am aware the only reference to the Temora appears in the catalogue of the collection of meteorites in the Natural History Museum of Vienna, that has just been published.‡ Slices of these four meteorites were recently acquired for the Vienna collection by an exchange with the Mining Museum, Sydney. They have been examined by the distinguished specialist in charge of the unrivalled collection there (Dr. A. Brezina), who is of opinion that Bingera, Cowra, and Temora have very considerably enriched our knowledge of meteorites; they are not only of very scarce types, but one, at least—Bingera—is almost unique.

Before proceeding to refer more particularly to these meteorites, it will be advisable to give an outline of the classification adopted by Dr. Brezina. All meteorites fall into two classes, according to the relative proportions of the stony and metallic (principally iron) constituents. Those in which iron predominates are subdivided into four groups, of which the three last—the Octahedrites, the Hexahedrites, and the Ataxites, are entirely metallic. As the irons to which this paper specially refers are all classified with the Octahedrites and Hexahedrites, the other divisions will not be considered further. The members of the Octahedrite

* The Minerals of New South Wales, p. 218. (8vo., London, 1888).
† Journ. R. Soc. N.S. Wales for 1893 [1894], XVII, pp. 82-88.
‡ Annalen des k.k. naturhistorischen Hofmuseums, 1896, X, Heft 3 u. 4.

division, when etched on a polished surface, show the Widmanstätten Figures*, in which the constituent lamellæ follow the faces of the octahedron. Those of the Hexahedral division, when similarly etched, reveal a cubic structure and cleavage.

In the present edition of the Vienna Catalogue the classification of the Octahedrites is made to depend, as heretofore, almost entirely upon the width of the lamellæ; but it is Dr. Brezina's intention, in collaboration with Prof. Cohen, to adopt a more comprehensive scheme eventually. The present arrangement is regarded as conventional only, and the upper and lower limits of the different groups are not sharply defined. The abbreviated classification is as follows :—

I. STONY METEORITES.

A. **Achrondrites.** Groups 1–11.

B. **Chondrites.** „ 12–37.

C. **Siderolites.** „ 38–39.

II. IRON METEORITES.

D. **Lithosiderites.** Groups 40–42.

E. **Octahedrites.**

43 (Off); finest lines, lamellæ up to 0·1 mm. wide. **Cowra.**

44 (Ofv); fine lines, Victoria group.

45 (Of); fine lines, lamellæ 0·15–0·4 mm. wide. **Moonbi.**

46 (Om); medium lines, lamellæ 0·5–1·0 mm. wide.

47 (Og); thick lines, lamellæ 1·5–2·0 mm. wide.

48 (Ogg); thickest lines. Some of the lamellæ above 2·5 mm. wide. **Temora.**

49 (On); Netschævo group.

50 (Obz); breccia-like, Zacatecas group.

51 (Obc); „ Copiapo group.

52 (Oh); Hammond group.

F. **Hexahedrites.**

53 (H); normal.

54 (Hb); breccia-like.

55 (Hca); Capeisen group.

56 (Hch); Chesterville group. **Bingera.**

G. **Ataxites;** more or less structureless; groups 57–61.

* The three iron-nickel alloys, upon the different resistances of which to the action of acids, and to their mutual arrangement in the mass, the etched figures depend, are kamacite or balkeneisen, taenite or bandeisen, and plessite or fülleisen. Kamacite forms "beams" which are bounded by a narrow envelope of bright taenite, the two together constituting "lamellæ" which lie in a field of dull-grey plessite, and upon the orientation of which the division into octahedral and hexahedral groups depends. While the relative proportions of iron and nickel in kamacite may be approximately taken as about 15:1, in taenite it falls to 3:1; plessite resembles kamacite in ultimate composition.

Cowra.—An iron weighing 12¼ lb., and with a specific gravity of 7·802—a little higher than that of metallic iron. No analysis has been made as yet. This meteorite is exhibited in the Mining and Geological Museum almost intact. Portions sufficiently large to illustrate its structure are contained in the London and Vienna Collections, and will shortly be also available in America; thereby affording opportunities for the study of this rare type of meteoric iron. The credit of discovery is due to a Mr. O'Shaughnessy, who found the meteorite firmly embedded it the slate rock with only one point projecting above the ground at the summit of Battery Mountain, at the junction of the Burrowa and Lachlan Rivers, a few miles east of the town of Cowra. It subsequently passed into the hands of the District Road Superintendent, Mr. A. J. C. Single, from whom it was acquired—probably about September, 1888—for the Mining Museum by Prof. T. W. E. David, B.A., then an officer of the Geological Survey Branch of the Department of Mines. A front-view photograph, taken from an accurately-made cast by Mr. F. C. Wills, is reproduced in Plate VII, while the appearance presented by an etched polished surface is illustrated by photographs—natural size, and enlarged—in Plate VII, Figs. 1, 2.

The Cowra is classified by Dr. Brezina as a sub-group of group 43—that with finest lines—of the Octahedrites.* It is referred to as being of very peculiar structure.† The ground mass consists of thick grey plessite, in which lie somewhat porous crystals of schreibersite ‡ of considerable size, surrounded by an envelope of taenite 0·5 mm. wide. Together with these larger crystals of schreibersite there are countless small skeletons with kernels of kamacite or schreibersite apparently arranged octahedrally. For a distance of about a millimetre all round the larger schreibersite crystals the plessite ground mass is free from the little skeletons, then tiny specks of taenite appear, the little skeletons coming in gradually. Round the smaller crystals of schreibersite the ground mass is similarly clear for a distance of from one to three millimetres; then appears a ring of taenite specks, after that more clear ground-mass, and finally the thick meshwork of skeletons.

An iron of somewhat similar structure is that known as the Butler, found in Missouri, U.S.A., in 1874.

Moonbi.—Of this meteorite the Mining Museum possesses only a few shavings, it having been acquired for the Technological Museum, Sydney. An account of its discovery and composition will be found in Mingaye's paper.§ It is an Octahedrite with lamellæ varying in breadth from ·4 to ·5 mm., thus approximating to group 46—that with medium lines; but the strong development of the plessite field leads to its being at present classed with many others in group 45—that with fine lines.‖ Grains of cohenite ¶ and kamacite are occasionally noticeable.

* *Op. cit.*, pp. 235, 267, 306.
† *Ibid.*, p. 267.
‡ Schreibersite is a phosphide of iron and nickel.
§ *Op. cit.*, pp. 82, 83.
‖ *Op. cit.*, pp. 235, 268, 272, 307.
¶ Cohenite is a carbide of iron, nickel, and cobalt.

Temora.—The Mining Museum possesses a small fragment of this iron, presented by Mr. W. A. Dixon, F.C.S. It was brought to that gentleman by a prospector during the time of the rush to the Temora diggings (about the year 1880). It appeared to have been broken off a larger mass, and was said to have been found between Cootamundra and Temora, possibly in the vicinity of Narraburra Creek. A complete analysis has not been made ; but an old label describes it as containing 95·79 per cent. of metallic iron, and 4·11 per cent. of nickel and cobalt. In addition to the piece in the Vienna Museum, there is a fragment in the private collection of Professor A. Ward, of Rochester, U.S.A. This is an octahedrite of very rare type, only one other—that found at Seeläsgen, Prussia, in 1847—being previously known. The Widmanstätten Figures are from 2 to 20 mm. wide, it thus coming under group 48—that with thickest lines, of the octahedrites.* Irregular beams of kamacite are separated by streaks of taenite. The kamacite is hatched and very rich in rhabdite.† Photographs, natural size and enlarged, are reproduced as Pl. VIII, Figs. 5 and 6.

Bingera.—This remarkable pear-shaped iron meteorite has already been described by Prof. A. Liversidge, F.R.S., as referred to above. It is now in the Mining Museum, reduced to one-third of its original size. The Vienna Collection includes a representative slice. Dr. Brezina compares it in shape to the Charlotte iron that fell at Nashville, Tennessee, U.S.A., in 1835.‡ In structure it is almost unique, an iron found at San Francisco del Mezquital, Mexico, in 1867, alone resembling it. Unlike the Cowra, Moonbi, and Temora irons, it belongs to the Hexahedrites, coming under group 56—the Chesterville, characterised by plates of schreibersite or rhabdite, regularly orientated, and uniformly distributed through the mass. It is described in the Vienna Catalogue § as showing on an etched face a fine-grained zone of alteration from 1·3 to 2·5 mm. broad, extending along the whole periphery. Internally it possesses a somewhat finely granular structure, giving rise, through the different orientation of the grains, to a bright glimmering reflection (brighter than in the case of the allied Mexican iron). Numerous orientated fine lamellæ, up to 10 mm. in length, are bounded by granules, partly isolated, and partly arranged conformably to rows of schreibersite lamellæ.

From the appearance of the skin of melted material with which it is coated, Dr. Brezina considers that the Bingera was found soon after its fall.

For the photographs reproduced in Plates VII and VII, I am indebted to Mr. F. C. Wills.

* *Op. cit.*, pp. 235, 288, 302.

† Rhabdite is a phosphide of iron and nickel, and occurs as minute tetragonal prisms arranged parallel to the edges of the cube.

‡ *Op. cit.*, p. 294.

§ *Loc. cit.*, p. 294.

XI.—Notes on the General and Economic Geology of the Coast between Port Macquarie and Cape Hawke: by J. E. CARNE, F.G.S., Geological Surveyor.

THE distance between Port Macquarie and Cape Hawke is about sixty miles, but following the contour of the shore-line it is, approximately, not far short of 100 miles. Port Macquarie lies about 150 miles south of the Esk and Jerusalem Creeks auriferous coast areas, which at the present time are attracting considerable attention.

Physical Geography.

The coast-line from Port Macquarie to Cape Hawke is destitute of any continuous cliff-sections, the few headlands which occur—such as Grant's Head, Camden Haven, Diamond and Crowdy Heads, Wallaby and Halliday Points, and Cape Hawke—are widely separated by long stretches of sandy beach fringing lowland areas.

The principal elevations adjacent to the coast are the conspicuous isolated mountains known as the North, South, and Middle Brothers, near Camden Haven and Stewart Rivers; and further west the Kerewong or Broken Bago Range, trending north-easterly towards Port Macquarie. Between the Manning and Wolumba Rivers, Talawahl and other peaks towards Tinonee and Coolongolook are conspicuous elevations above the general level.

The principal drainage channels entering the sea between the extreme points of investigation are the Hastings and Wilson Rivers, entering at Port Macquarie; the Camden Haven and Stewart Rivers at Camden Haven; the Manning River, with its divided outlet, at Harrington and Farquhar Inlets; and the Wollumba River, entering at Cape Hawke.

The above rivers, with their principal tributaries, drain a large tract of country lying between the Macleay watershed on the north, Cape Hawke on the south, and the high lands of New England on the west. Included in this area are portions of the Orara, Gyra, and almost all the Gloucester Gold-field, as well as the Gundle Tin-field on the Wilson River.

Between Tacking Point and Diamond Head are five lakes close to the sea-line, four of which are of considerable size. Lake Innes or Burrawan, Lake Swamp, and Cathie Lake lie nearest to the coast, from which they are separated only by swampy, sandy areas. These lakes lie opposite the long beach between Tacking Point and Grant's Head. Queen's Lake and Watson-Taylor Lake are tidal waters connected with Camden Haven River; they lie north and south of the North Brother, at a distance of about three miles apart, and one and a half from the coast.

General Geology.

The geological formations represented in the coast section consist of Carboniferous marine beds at Cape Hawke, Halliday, and Wallaby Points; fresh-water Mesozoic beds at Camden Haven, Grant's and Crowdy Heads; and Tertiary and recent deposits in the low-lying intervening areas.

Igneous rocks are represented by serpentine and dolerite at Port Macquarie, and felsite, rhyolite, and diorite at Diamond Head.

Between Port Macquarie and Tacking Point, patches of altered sedimentary rock occur in contact with serpentine and dolerite. The Signal Station at the former, for instance, stands on a peninsula of such a rock where the junction with the serpentine is well marked. The sedimentary rock, owing to intense silification induced by igneous intrusion, has in places assumed cherty, chalcedonic, and jasperoid characters.

At Nobbies, the South Head of Port Macquarie, across a narrow neck connecting the headland with the mainland, several shafts have been sunk in the altered rock where it is much decomposed. In one of them a mass of loose, rubbly quartz has been opened up, evidently under the impression that it was a vein; but a glance at the large solid masses of similar material lying at sea-level on the west side of the neck, is sufficiently convincing of its secondary character. In some instances the infiltration of the colloidal silica has converted the original rock into a homogeneous chalcedonic or jasperoid mass, in others it has reticulated it with thin seams and threads. A specially interesting example of complete silicic metamorphism is represented in some isolated rocks exposed on Tacking Point beach, at the site of the Wodonga wreck, the bedding planes of which are distinctly preserved, striking N. 52° E., and dipping N. 38° W. at 44°. Fragments of the silicified rocks and of true quartz occur loose or mingled with the deep red soil of the surface just above the beaches between Nobby's and Tacking Point, to which further attention will be given when the occurrences of gold are being considered.

Owing to contact metamorphism and absence of any palæontological evidence, the correct geological horizon of the above-described sedimentary rocks cannot be authoritatively determined at the present time, but from correlative evidence there is little doubt that they will eventually prove to belong to the Carboniferous Period.

Carboniferous Marine Beds.—Rocks of this age form the headlands at Cape Hawke, Halliday, and Wallaby Points, and a smaller unnamed headland just north of the latter, where these rocks are first seen in the coast section when followed southerly from Port Macquarie.

The strata consist of alternating beds of indurated sandstones and mudstones, with intercalated beds of coarser grits and conglomerates.

The prevailing strike at Cape Hawke—where the largest outcrop occurs—is about 1 degree from east and west. The dip is southerly, but variable in amount, ranging from 30° to 52°. At the low headland above mentioned the strike is apparently nearer north-west, but here the strata have been subjected to anticlinal and synclinal folding.

Wallaby Point consists chiefly of massive beds of indurated sandstones, grits, and conglomerates. A special feature of this outcrop is the curious concretionary weathering of some of the sandstones. Hard cores of greenish-gray colour are seen embedded in weathered yellowish-brown shaly layers from $\frac{1}{16}$ of an inch in thickness. The cores vary in size from small pellets to massive blocks, according to the thickness of the individual beds. The concretionary or rounded structure assumed in weathering probably arises from a series of parallel cross-joints or shrinkage cracks at right angles to the bedding planes, which divide the rock into blocks, and allow free access of the weathering agencies to the whole superfices, which would naturally tend to the rounding of the angles in the manner displayed by the beds in question.

From the strata exposed in the coast section, near the signal-station at Forster, Cape Hawke, a number of fossils were collected, which have since been examined by Mr. W. S. Dun, Assistant Palæontologist, who has supplied the following notes:—

" The fossils collected by Mr. Geological-Surveyor Carne, from near the Flagstaff, Parish of Forster, County Gloucester, indicate rocks of true Carboniferous age. They are mostly imperfectly preserved as casts and impressions.

Chonetes, sp. (Very closely allied to *C. hardrensis*, Phillips, of the English Carboniferous.)

Productus semireticulatus, Martin.

Spirifera. (A few specimens which indicate a species of the type of *S. grandicostata*, McCoy.)

Gosseletina australis, Eth. fil.

Fenestella.

Orthoceras. (Remains of an internal cast of a very large species, showing remains of two septa; about 7 inches wide, as preserved.)

Corals. (Very abundant; occurring as internal casts, evidently of a branching dendroid form.)

Bellerophon.

Entolium ?

Knorria.

From the neighbourhood of Cape Hawke Mr. Etheridge has already recorded *Cyrtina carbonaria* var. *australasica*, Eth. fil., *Productus cora*, D'Orb., and *Leptodomus*.*"

The identification by Mr. Dun, of the fossils *Productus semireticulatus*, and *Gosseletina australis* in abundance in the Cape Hawke Carboniferous rocks is of special importance, because such forms are typically characteristic of the beds beneath the Productive Coal-Measures (Permo-Carboniferous) of New South Wales. Thin coal seams, however, do occur in the Carboniferous beds, but so far as the present state of our knowledge goes, of inferior, unworkable quality only.

Mesozoic—Clarence Measures—The cliffs forming the headlands north and south of Camden Haven and at Crowdy Head belong to this period. At the first-mentioned the strata consists of massive conglomerates and sandstones, with fine shaley sandstones and clay shales, and are specially distinguished by general horizontality and by the highly ferruginous character of the conglomerates and sandstones. The latter feature has given rise to an erroneous belief that beds of iron ore and ochre of economic importance occur here.

Crowdy Head, situated about eight miles north of the main outlet of the Manning River consists of more or less horizontally bedded massive gray sandstones, in which reed-like stems (probably *Equisetum*) are occasionally exposed during quarrying operations now being carried on in connection with the construction of retaining-walls at the entrance of the Manning River at Harrington.

The dip of the Mesozoic strata is to the south-west; at Grant's Head it amounts to about 7° only from the horizontal.

The conglomerates consist essentially of chalcedonic quartz and jasperoid pebbles in a cementing paste of sand and oxide of iron, the latter rendering some portions extremely compact and hard.

At the southern end of the south head of Camden Haven where the cliffs give place to the beach which stretches to Diamond Head, the section consists of massive beds of the conglomerate overlying a thick bed of very ferruginous clay shale, which in turn overlies a grey sandy shale containing plant remains, and a few thin streaks of coal about half an inch thick.

In a collection of plant remains from the latter, Mr. Dun determined the following well-known forms:—

"(*a*) *Thinnfeldia odontopteroides*, Morris.

(*b*) *Alethopteris lindleayana*, Royle.

(*c*) *Equisetum*.

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* Records Geol. Survey N.S. Wales, 1892, III, p. 60.

(*d*) *Cycad.* (Frond imperfectly preserved, the bases of the pinnules being indistinct. Probably a *Ptilophyllum*. *P. oligoneurum*, Ten. Woods, occurs in the Ipswich Coal-Measures of Queensland.)

(*e*) *Gleichenites?* There is also present a fern with small lobate pinnules, somewhat similar to *Didymosorus* (*Gleichenites*) *gleichenoides*, Oldham, from the Rajmahal Coal-Measures, (Lower Mesozoic), of India, but differing from it in the distance apart of the pinnæ and their less bead-shaped and more elongate form but it is very indistinctly preserved. This species (Indian) has been also described from the Desert Sandstone of Croydon, Queensland.

(*f*) *Cardiocarpum.*

(*g*) *Phyllotheca* sp. This form is unlike any that has hitherto been described from Australian Mesozoic rocks. It is characterised by the very elongate fine leaf bracts, and the narrow stem. It is of the type of *Phyllotheca deliquescens*, Schmalhausen, from the Jurassic of Western Russia, and *P. sibirica*, Heer, from rocks of similar age in Siberia."

The fossils identified establish the Mesozoic age of the rocks on the coast at Camden Haven, and, therefore, point to the possibility of strata of the Productive Coal-Measures (Permo-Carboniferous) underlying them. This question will, however, be further considered under the head of coal.

Igneous Rocks.—I am indebted to Mr. G. W. Card, A.R.S.M., Curator of the Mining Museum, for the following petrographical notes on igneous rocks from the localities mentioned:—

[819] 53-mile peg—Port Macquarie to Taree Road. Ophitic dolerite (olivine absent.)

[820] First point south of Nobby's, near Port Macquarie. Similar to 819, but coarser in grain.

[821] Tacking Point, (by some regarded as granite, J.E.C.) Similar to 820, but less ophitic in structure and much altered. Would appear to be of considerable geological age.

Note.—These three [819, 820, 821,] would be termed diabase by some. The absence of olivine brings them somewhat nearer the diorites.

[823] Diamond Head. Diorite.

Mr. Card also confirmed my field determinations of the Diamond Head quartz felsites, and the silicified fine-grained sedimentary rock already described.

Economic Geology.

The economic metals and minerals represented in or near the coast-line between Port Macquarie and Cape Hawke consist of gold, copper, cobalt, manganese, iron and limestone, which will be dealt with in due order, and followed by reference to the reported occurrence, and probable existence of coal and kerosene shale.

Gold.—Gold naturally first claims attention, not, however, because of any importance attaching to the beach-mining operations which have hitherto been attempted. It occurs in reefs at Coolongolook, and Paddy's Creek, near Bungwall, west, and a little south-west of Cape Hawke, in rocks of Lower Carboniferous age. In Bunt and Ort's Claim, at Paddy's Creek, the gold-reefs occur as thin flat-lying veins in conglomerate, which caps at this point the claystones and slates in which the neighbouring reefs occur. At Coolongolook the gold reefs are thin and have been mostly characterised by the occasional occurrence of very rich, but extremely small shoots; a mode of occurrence usually if not invariably leading to loss and disappointment. The regular persistence of good stone with depth in the Curriki Reef should, however, encourage prospecting at lower levels. Coming nearer to the sea-beaches, gold in the matrix, or more correctly, loose gold derived from local matrix, has been found in fairly coarse pieces, at intervals, between Nobbies and Tacking Point, near Port Macquarie, where, as before stated, igneous and sedimentary rocks occur in contact. The gold is here found in the red soil and rubble which covers the surface and accumulates as small taluses at the foot, of the elevated land at the back of the beaches. In December last, a local resident, Mr. A. Wade, pointed out several localities further inland where prospects were obtainable.

Both the igneous and sedimentary rocks, as before mentioned, are seamed with small veins, chiefly of a secondary or chalcedonic silica, in which pyrites is rarely seen. From a few of the most favourable-looking, samples were taken, which, however, failed to reveal the presence of gold on assay. That the gold obtained under the conditions stated differs distinctly in character and derivation from the uniformly minute particles in the beach sand, is easily apparent to those who occasionally find it when trying the latter at the junction of the red soil.

The indications in this locality point to dissemination of gold in small quantities through the country rather than concentration in defined matrices or reefs. The loose gold of the red soil probably represents the naturally concentrated yield of a large amount of weathered and denuded country.

At Diamond or Indian Head, two distinct intrusions of igneous rock occur in conjunction, the oldest consisting of diorite, and the younger of quartz-felsite. Rhyolite occurs in the latter, filling an irregular fissure, through which it has welled up in well-marked lines of viscid fluxion structure.

On the surface of the quartz felsite, crystalline quartz veins occur, having a maximum thickness of from one to one and a half inches in thickness; the apices of the crystals are free, symmetrical, and perfectly transparent, hence, perhaps, the name of "Diamond" Head. Pyrites is associated with portions of the country and some of the veins. The discovery of the quartz veins and pyrites caused a small rush to the locality, and a number of shallow shafts and trenches were sunk on the top and western falls of the head-land, but the indications are decidedly unfavourable both as regards the character and permanence of the veins.

Marine denudation has exposed the quartz felsite to a depth of three to four hundred feet in the coast section without revealing any favourable mining indications. It is true that the felsitic intrusion in its composition is allied to the Pambula auriferous rock, more especially as regards the very thin and limited rhyolitic bands; but this approximate resèmblance counts for nothing unless gold occurs in the mass itself, which there is at present no ground for assuming.

Beach Gold Mining.—So far as could be ascertained, remunerative beach-mining has only been possible in about three localities between Port Macquarie and Cape Hawke, viz., Tacking Point Beach, Camden Haven, and Harrington Inlet; and even in these cases for very limited periods and yields only. The most important—Harrington Inlet—yielded about £70 worth of gold before the supply of material was exhausted. Messrs. Atkinson and Hannay discovered the deposit about fifteen months ago just north of the retaining wall now being constructed. The auriferous sand extended for about four hundred yards along the shore-line at, and near, sea-level. The bluish layer of "sniggers," averaging from four to fifteen inches in thickness, rested on altered sandstone, and filled its numerous joints and crevices.

On Tacking Point Beach, near the "Wodonga" wreck, Osbiston Brothers last year worked a "snigger" deposit for a reported yield of twenty ounces, which exhausted the present supply of workable sand. The best results were obtained from the deepest layers, which averaged from one to two inches in thickness under from five to ten feet of stripping. This party had just removed to Camden Haven Beach, where at the most rations were formerly made.

Messrs. Woods and Partner have cut a race about one and a half miles long, taking advantage of the course of a small creek which trends northerly behind, and parallel to, the coast dunes, for the purpose of ground-sluicing a deposit of sand close to Tacking Point. At the head of the race a small conserving dam has been constructed, from which the water had just been turned on, the volume being

about equal to two sluice-heads. On the beach, plates and boxes have been laid on the sand, coir matting and blanketing are both used for lining the boxes and the bed of the race above the plates. Judging from the altogether ineffective fall of the water and its consequent gentle silting effect on the plates and boxes—which were almost entirely buried beneath the drifted sand, and the extreme liability to damage by even moderately high tides and gales, nothing but failure can be predicted for this venture, even if the deposit is a payable one, which has yet to be demonstrated. A little of the blanketings or concentrates supplied by one of the party—which, however, was not regarded as altogether a fair sample—yielded no trace of gold in the Departmental Laboratory. This evidence is only an indication of poverty not of complete absence of gold, for the gold particles being free might—if few—be missed in sampling.

At Nobbies a few pot-holes have been sunk for gold amongst rounded boulders and pebbles, but with what result is not known. A noticeable feature is the association of well-worn pebbles and shingle with the auriferous black sand in almost every instance where it occurs on the beaches.

In June, 1894, a prospector named Warbrick began testing the sand inside the Old Bar, at the entrance of the south channel of the Manning River, at Farquhar Inlet. His operations attracted attention, and caused a small rush of about thirty men; few, however, remained after a short interval. The only protracted trial being that of Messrs. Crofton and Party, who worked intermittently for about seven months, their chief efforts being concentrated in a small depression about seventy-five yards back from the beach, close to the border of the mainland. Here the sinking is about seven feet, in dry, clean, sand; the bottom consists of stiff pug-clay, with pebbles derived from the conglomerate beds of the country. The black sand layer exposed in the bottom of a shaft sunk at the time of inspection averaged from ten to thirteen inches in thickness. The same party also worked for a time on the beach opposite the Recreation Pavilion. Holes sunk at this spot as deep as the water would allow revealed extremely fine thin layers of black sand, alternating with ordinary white quartz sand. In working, however, the whole available thickness of black and white layers would have to be operated on, because separation would be impossible. Shovel-panning of selected samples yielded a few very minute gold specks, but no platinum.

Evidences of the existence of earlier beaches landwards.—In two localities, viz., Tacking Point Beach, north of the outlet of Cathie Creek, and the beach near the outlet of Khappinghat or Saltwater Creek, between Wallaby and Halliday Points, there is evidence of Recent and Tertiary sea-made areas extending inland. At the

foot of the beach dunes in these localities, a hardened black sand-bed occurs about, and a little above, sea-level, consisting of ordinary quartz-sand, grains coloured and cemented by organic matter and iron salts. The essential differences between these and similar occurrences in the Esk River District are the extreme poverty of the present beaches opposite these outcrops, and the conspicuous rarity of the genuine black sand (titanic iron and zircon) which forms such a common and characteristic feature of the more northern auriferous beaches. In fact, this constant associate of the gold particles becomes markedly less and less discernible as the coast line is followed southwards from Port Macquarie.

It is true that Osbiston Brothers reported a yield of twenty ounces of gold for twelve months' work from a patch of natural concentrates or "sniggers" on Tacking Point Beach, just about the north end of the "black rock" outcrop; but opposite the outcrop itself no good results were obtainable.

At the other locality mentioned, near Saltwater Creek outlet, the "black rock" rises in some places to a height of six feet above the beach level, and through it fresh water is continuously soaking from the made ground at the back. A feature of this outcrop is the occurrence in it of large, altered sandstone pebbles, mostly in layers, which would render testing by sludger extremely difficult, if not impossible.

Iron salts play an important part in the colouration of this bed, and where such have been converted into peroxides at the exposed outcrop, the rock is of a yellowish or reddish-brown hue.

On the banks of Saltwater Creek outlet, and for a very limited distance south, thin layers of the true black sand occur. An average sample taken carefully from the surface layers—which cake as they dry in the sun—yielded a trace of gold only when tested in duplicate in the Departmental Laboratory. From the position of the true black sand at the base of the loose sand of the dunes, and its marked absence on the beach opposite the long outcrop of "black rock," it would appear as if it were derived from the former.

A large swamp closely parallel to the beach south of Old Bar was regarded by some as evidence of a former encroachment of the sea, but a very slight test was sufficient to disprove this conjecture.

I am indebted to Mr. Hannay, of Taree, for the following particulars of the nature of the sinking about two hundred yards inland from the mouth of Abby Creek between Diamond and Crowdy Heads:—

Wind-blown sand	2′ 6″
Boulders and sand with fine gold particles	2′ 0″
Chocolate-coloured slimy sand	6′ 0″
Coarse gravel with coarse colours of gold regarded as bottom	....

Three men were engaged here partly in trying the beach sands at the creek mouth, and partly in prospecting in the neighbourhood.

Absence of Basalt-covered Drifts.—In the strip of country under consideration there is apparently an entire absence of basaltic outflows covering earlier drainage channels. The original richness of the sea beaches adjacent to such phenomena in the Richmond and Tweed River Districts, and their gradually but surely increasing poverty in ratio with the distance from those localities, adds immensely to the importance of the drifts as a source of the beach gold, and to their undoubted influence on the richness of adjacent beaches.

In a previous report* I dealt with the question of the origin of the beach gold. The opinion therein expressed has been strengthened by phenomena observed during recent examination of beach areas further south. Such an opinion, however, can be but a tentative one, to be confirmed or rejected by future detailed survey and observation. The tests being carried out at the present time in the Tertiary and Recent sea-made areas, under the able and careful supervision of Mr. D. Munro, should afford valuable data for future guidance.

Metals other than Gold—Cobalt Ore.—Nine or ten years ago cobaltiferous manganese oxide (Wad) was discovered by Mr. E. H. Becke, at Nobbies, Port Macquarie, which attracted some attention because of the establishment at Sydney about that date of works for treatment of ore of a similar composition from near Bungonia (where it occurs as a cementing material, and in small concretionary nodules, in a coarse grit); but the nature of the ore, its chief mode of occurrence being thin coatings, stainings, and encrustations in the joints and divisional planes of serpentine, renders it extremely doubtful whether any form of mechanical treatment could be successfully adopted. The ore was first detected in the serpentine country at Windmill Hill; and street cuttings and levelings reveal its presence in the town of Port Macquarie itself.

Iron Ores.—With the cobalt ore is associated a little magnetic iron ore, which, in some places, is altering into soft red iron ochre (red hematite), having a deceptive appearance to some of the uninitiated, who are apt to mistake it for cinnabar. The rich red colour of the neighbouring soil is most probably due to the above chemical or molecular change.

At Tacking Point, at the foot of the cliffs on the south side, magnetite occurs as a crust of no great thickness, which, when broken, reveals an altered rock highly charged with pyrites.

* Ann. Rept. Dept. Mines and Agric. N.S. Wales for 1895 [1896], pp. 149–160; see also *postea*, pp. 71–86.

At Honeysuckle Flat, close to the 43-mile peg on the Port Macquarie-Taree Road, magnetite occurs as gravel, both loose and in fairly large cemented lumps. Its physical character is very deceptive, causing it to be readily mistaken for ordinary brown iron ore (limonite). The occurrence is in a low flat of serpentine country, which here has a width of about twenty-five chains. The iron-ore gravel has doubtless been shed from the serpentine, and concentrated and partly cemented in a swampy area; judging from the road trenches, the deposit appears to be very superficial.

Copper.—About twenty-five years ago attention was directed to a deposit of copper and iron sulphides at Nobbies, Port Macquarie, and a shaft was sunk, but evidently without satisfactory result, for operations were not continued. A few broken specimens, chiefly of iron sulphide, near a later opening, is all that is now visible, hence no opinion can be offered.

Copper ore is also reported from Hanging Rock, about three miles west from Green Hills, but this site, through inadvertence, escaped attention.

Coal and Kerosene Shale—Reported Discoveries.—Local reports are current as to several separate discoveries of coal and kerosene shale, generally in loose pieces. About three years ago Mr. A. McLeod reported finding loose specimens of kerosene shale on Broken Bago Range, which resulted in four sections of land being applied for by a Sydney mining agent; later, these areas were re-applied for; but in neither case does actual prospecting appear to have been done. Loose drifted specimens of kerosene shale are also reported from near Saltwater Creek, at some distance from the coast.

Coal has been reported from the headlands at Camden Haven, and substantial accounts given of burning tests. These headlands, as already stated, consist of Mesozoic rocks. Whether a coal-seam does actually outcrop beneath them at or below sea-level I am not prepared to dispute, because I did not follow the headlands completely round their sea-face, being blocked in one instance by the sea, and in the other by the approach of night. It is probable, however, under the circumstances, that the reported coal was from the thin coal-streaks near the plant-beds already described in this report.

The identification of Secondary (Clarence) beds at Camden Haven and Crowdy Head opens up an interesting question relative to further extension of our already extensive coal-basins. Looking at the Broken Bago Range, from Wauchope, attention is at once arrested by the bold, vertical, western escarpments of the range towards Mounts Kerewong and Combine, a feature which affords reasonable

presumption for the existence of horizontal beds, and which is strengthened by the later determination of Mesozoic strata on the coast at Camden Haven. The isolated Brother Mountains will also probably prove of this period. The coast outcrop is of little importance, because of its limited extent; but greater scope is afforded by the Broken Bago Range, which, if proved to belong to the same period, may overlie productive coal-measures. A special detail examination would be necessary to determine this interesting and important question.

XII.—Additions to the Permo-Carboniferous Coal-measure Flora of New South Wales: by W. S. DUN, Assistant Palæontologist.

[Plate IX.]

THE characteristic and protean genus *Glossopteris* appears to become more bewildering in accordance to the number of specimens examined; in fact, as has already been pointed out by Mr. R. Etheridge, Junr., the whole question, both as regards generic rank, specific characters and synonymy, is now most hopelessly involved.* As far as the Australian forms are concerned the species already described number eighteen, and nothing but the marked dissimilarity of the two forms herein mentioned would warrant the establishment of two new species to a list of which probably half the specific names are invalid and the generic uncertain.

II.—Descriptions.

Glossopteris, Brongniart, 1828.

(Prodrome Hist. Veg. Fossiles, p. 54.)

Glossopteris rectinervis, sp. nov.

Sp. Char.—Leaf elongate-lanceolate, midrib strongly marked, secondary veins very reticulate, fine, leaving the midrib almost or quite at right angles. Reticulations irregular, meshes long and narrow at centre between midribs and margin, not elongate, but small along the margin. Apex unknown. Stalk unknown.

This species is very different from any other form occurring in the Australian or Indian Plant-beds, so much so that it seems advisable to consider it as a distinct species, as it would not fit in as a variety of any hitherto described leaf. It cannot be compared to any New South Wales form, unless we can imagine *Glossopteris parallela*, Feistm,† on a much smaller scale, with the venation springing at right angles from the midrib.

As far as the direction of the veins is concerned, attention may be drawn to the condition obtaining in *G. divergens*, Feistm.,‡ though it differs from *G. rectinervis*

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* Proc. Linn. Soc. N. S. Wales, 1894, IX (2), pp. 228-249.
† Mem. Geol. Survey N.S.W., Pal. 3, 1890, t. 18, f. 3.
‡ Pal. Indica, Ser. XII, Vol. III, Flora of the Damuda and Panchet Divisions, 1881, p. 104, t. 280, f. 3, 4.

both in outline and mode of anastomosis of the veins. The direction of the secondary venation also resembles that of *G. divergens* in being, at the base, directed downwards, at the centre of leaf at right angles, and towards the apex, more upwardly.

The outline agrees somewhat with that figured by Feistmantel * in a specimen of *G. damudica*, Feistm., but the same differences, separate *G. rectinervis* from this species as from *G. parallela*.

But the greatest resemblance to a member of the Indian Gondwana Flora appears to be in *G. stricta*, Bunbury, from the Raniganj Group. † In general form, apart from the greater size of *G. stricta*, there is very little difference; but Feistmantel, in describing the reticulation in the Indian form, speaks of it as passing " out from the midrib at a pretty acute angle." This form has been recorded by the same Author from the Beaufort Beds of South Africa. ‡

The specimens of this species were collected by Mr. C. Cullen, at the Ward River, County of Gloucester, in beds belonging, most probably, to the Upper or Newcastle Coal-Measures. The Coal-Measures occur here as small outliers, and have been described by Professor T. W. E. David as being referable to either the Newcastle or Tomago Coal-Measures, or possibly to a combination of the two. §

(*b*) *Glossopteris acuta*, sp. nov.

Sp. Chars.—Leaf imperfect, base not shown; elongate, acute, delicate; apex pointed; midrib fairly strong; reticulations inclined at an angle of about twenty-five degrees with the midrib, about five in the space between the midrib and margin; reticulations approaching to margin in some cases; nerves in some cases joined by well marked cross-bars as well as the reticulations.

This is an exceedingly graceful form of leaf, and cannot be assigned as a variety to any hitherto-recorded species of *Glossopteris*. Its most characteristic feature is the extremely acute and apparently delicate apex.

In by far the greater majority of cases the apex of *Glossopteris* is rounded, and as an instance of a more pointed apex we may take *G. indica* as figured by Feistmantel, ‖ though this is typical in being rounded, and not acute as in our species. The venation is, on a small scale, like that of *G. conspicua*, Feistm., ¶ of the Raniganj Group. It differs from the same Author's figures of Brongniart's *G. augustifolia* ** in the form of the leaf, the lesser development of the midrib, and the arrangement of the reticulation.

The specimen is preserved in fine grey laminated sandstone, and was obtained by Mr. E. F. Pittman in the first Cremorne Bore, at Robertson's Point, Sydney, at a depth of 2,900 feet. in the Newcastle or Upper Coal-Measures.

* *Loc. cit.*, t. 31 a., f. 1 (non. 2 and 3.)
† *Op. cit.*, p. 100, t. 37a, f. 1 & 2.
‡ Abhand. K.B. Gesell. Wissensch., 1889, Folge VII, Bd. III, p. 45, t. 4, f. 6, 6a.
§ Ann. Rept. Dept. Mines N.S. Wales for 1889 [1890], pp. 219-221.
‖ Pal. Indica. III, t. 27a, f. 3.
¶ *Op. cit.*, t. 28a, f. 1.
** *Op. cit.*, t. 39a., f 1, 1a, 2,

XIII.—Mineralogical Notes, No 5: by GEORGE W. CARD, A.R.S.M., F.G.S., Curator and Mineralogist.

1. Telluride of Bismuth from Tarana and Uralla.
2. Martite from Byng.
3. Apatite from Gordonbrook.
4. Jamesonite from Bolivia, New England.
5. Prehnite from Dapto.
6. Chromite in Felsite from Barraba.

1. *Telluride of Bismuth from Tarana and Uralla*:—At Tarana the mineral was first noticed by Mr. E. C. Whittel, Field Assistant, at Mitchell and Party's Claim near Slippery Creek. It occurs along with free gold in small grains and flakes in the quartz, and is associated with greenish and yellow alteration products. The Telluride is most probably auriferous.

A similar mineral has recently been found, also associated with free gold, in a white quartz from Kentucky Run, near Uralla. Telluride of Bismuth has been previously recorded from Captain's Flat, Molonglo, and from Moor Creek, Tamworth.

2. *Martite from Byng*:—Iron-grey sharply defined octahedral crystals, up to two millimetres in length, having a purplish-red streak, embedded in a soft yellowish-green soapy matrix which is traversed by strings of massive iron pyrites having an unusual tarnished appearance. Crystals of similarly tarnished pyrites also occur in the matrix itself.

3. *Apatite from Gordonbrook*:—Pinkish-white crystals associated with an actinolitic substance, described as occurring in narrow veins traversing granite. The crystals have the form of the di-hexagonal prism, and vary in size up to an inch across. With the exception of the minute crystals common in certain igneous rocks, apatite has hitherto been recorded in New South Wales from Broken Hill only, where it is associated with galena.*

4. *Jamesonite from Bolivia, New England*:—Jamesonite is now being found both massive and intimately associated with galena, at the Pye's Creek silver-lead mines. Its mode of occurrence is peculiar, in that it appears to be replacing galena. Lumps of the galena may be seen surrounded by a layer of, and traversed in all directions by strings of jamesonite, being in this way broken up into irregular fragments. An average sample of such a specimen yielded on assay seven per cent. of antimony, and forty ounces of silver to the ton.

* A. Liversidge, Journ. R. Soc. N. S. Wales for 1895 [1896], XXIX, p. 316.

5. *Prehnite from Dapto:*—In the excavations being made at Dapto for the works of the Smelting Company of Australia large masses of prehnite, sometimes associated with crystals of quartz, are found.

6. *Chromite in Felsite from Barraba:*—At Crow Mountain Creek, Barraba, the serpentine country rock has been traversed by felsitic dykes. The felsite is dotted over with specks of chromite, or contains spots of pale green chrome-bearing silicate of magnesia. Under the microscope the chromite grains are sometimes seen to be broken up and drawn out into contorted bands by the flow of the viscous lava. It would appear as if the intrusive material had eaten its way into the serpentine, partially assimilating the latter. The chromite grains being more indestructible remain more or less intact.

XIV.—On the Occurrence of the Genus *Chelodes*, Davidson and King, in the Upper Silurian of New South Wales: by R. ETHERIDGE, Junr., Curator of the Australian Museum, Sydney.

THE remains of Chitons in the Palæozoic, and for the matter of that also in the Mesozoic rocks of Australia, are conspicuous by their absence. Recently Mr. Charles Cullen, Collector to the Geological Survey, obtained two fossils from the Upper Silurian Series of Yass, agreeing in outline with the hitherto somewhat problematical plates knowns as *Chelodes*, Davidson and King, and its allies *Sagmaplaxus*, Œhlert, and *Beloplaxus*, Œhlert.

Chelodes has been ascribed at different times to a *Chiton* by Barrande, a provisional Brachiopod by Lindström, an Operculate Coral by Davidson and King, an *Aptychus* by Von Jhering, and lastly relations have also been suggested with the Cirripedia. More recently, however, Dr. G. Lindström has reconsidered the whole question, and after reading his clear exposition of the case,* it seems to me that the balance of evidence, as he suggests, is in favour of a reference to the Chitonidæ.

The fossils comprised within the three genera lately mentioned may be broadly stated to be oblong, trigonal, or subtrigonal angular plates, generally longer than broad, and arched (*Chelodes*, *Sagmaplaxus*), convex on the dorsal surface, concave on the ventral; or, although convex on the former, grooved in the middle line (*Beloplaxus*). The anterior end is broad, more or less truncate, and to a greater or less degree emarginate centrally, with the lateral anterior angles either rounded

* Sil. Gastropoda and Pteropoda of Gotland, 1884, p. 48.

(*Chelodes*, *Sagmaplaxus*), or sharp (*Beloplaxus*). On the other hand the apical or posterior end is strongly developed, acuminate, and terminating in an obtuse, or semi-obtuse point. The dorsal surface in all three bears growth lines or laminæ, concentric with the outline, but the ventral in all three is divided into two unequal portions. In the case of *Chelodes* and *Sagmaplaxus*, an anterior end of variable outline according to the genus, and a posterior that presents the appearance of a raised area, broadly V- or chevron-shaped, regarded by Lindström and Œhlert as an area of insertion. It is this peculiar space that probably suggested to the former of these authors, in the first instance, the reference of *Chelodes* to the Brachiopoda, by recalling the area of a ventral valve, or to the Lepadidæ by suggesting the "beak" of the tergum. *Beloplaxus*, on the contrary, has no broad chevron-shaped area on the ventral aspect, but instead, straight surfaces along the lateral borders from behind forwards. In the genera *Chelodes* and *Sagmaplaxus* at least, the edges of the plates are turned under, forming a narrow thickened border.

The most important feature about these plates, however, is that, unlike the generality of *Chiton* plates, they are all destitute of apophyses, and only in *Beloplaxus* has any trace of insertion plates been observed.

Both *Sagmaplaxus* and *Beloplaxus* were described* by Dr. Daniel Œhlert as the plates of Chitons, but Lindström believes that *Chelodes* and *Sagmaplaxus* "may be considered as ranging very near to each other," but judging merely from the figures, I am inclined to generically separate them.

Chelodes is typified by *C. Bergmani*, D. and K., from the Wenlock rocks of Gotland, and is there associated with a second species, *C. gotlandicus*, Lindström. In the Upper Silurian of Bohemia we meet with *C. bohemicus*, Barr. *Sagmaplaxus* and *Beloplaxus* are Devonian, the former (*S. sarthacensis*) coming from rocks of that age in France, the latter typified by *Chiton sagittalis*, Sandberger, from those developed in Nassau.

The Australian fossils (Woodcut, p. 70) I now refer to *Chelodes*, as the most fitting of the three genera for their reception, are silicified, thick, elongate (longer than wide), subtriangular, claw-shaped plates, arched, or obtusely geniculate in the longitudinal middle line, slightly curved from front to back, and with sharply sloping sides. The anterior margin is subtruncate and emarginate centrally, rounded at the sides, forming rather obtuse angles with the posterior lateral margins, which converge to a fairly acute posterior apex. Internally or ventrally the shell is divided into two unequal parts, as in *C. Bergmani* and *S. sarthacensis*, of which the anterior is by far the larger. The posterior area of imbrication is strongly chevron-shaped, the wings extending forwards as far as the angles formed

*Mém. Soc. Géol. France, 1881, II (3), No. 1. pp. 15 and 17.

by the junction of the posterior and antero-lateral margins. There is no striation or ridging apparent on this imbrication area, whilst the external sculpture of the whole dorsal surface is confined to indistinct traces near the anterior emargination of concentric laminæ of growth.

The plates differ rather in shape, one being much broader than the other, with its imbrication area varying accordingly. In neither of them is there any trace of an inturned border as described both by Lindström and Œhlert.

It will be manifest that as the plates are not grooved by a median sinus for the greater part of their length, nor a linear imbrication area, the genus *Beloplaxus* may be dismissed from discussion. Of the two other genera, I have selected *Chelodes*, from its general resemblance to the Yass plates, although the latter appear to be much stouter and more arched and massive than either of the three known species of *Chelodes*, although the formation of the imbrication area is the same. The latter character equally points to *Sagmaplaxus*.

In the absence of apophyses or sustentacula, the present plates agree with *Chelodes Bergmani*, *C. gotlandicus*, *C. bohemicus*, and *Chiton? cordatus*, Kirkby,* as well as *Sagmaplaxus* and *Beloplaxus*, and differ in this respect from the recent *Chitons*, and a large number of the other Palæozoic forms also.

The outline of the Australian plates differs widely from the recent Chitons, except, perhaps, such forms as *C. hastatus*, Sby., as pointed out by Kirkby and Lindström, *Ichnochiton alatus*, Sby., and *Schizochiton incisus*, Sby., &c., and many fossil species, although there are some which are similarly shaped. Amongst the latter may be mentioned certain species of *Pterochiton*, Carp. (*Rhombichiton*, De Kon.), for if the apophyses of these be removed, the resemblance is very strong, even the imbrication area in *Pterochiton* becoming very much wider and more triangular, reaching its greatest development in *P. gemmatus*, De Kon.

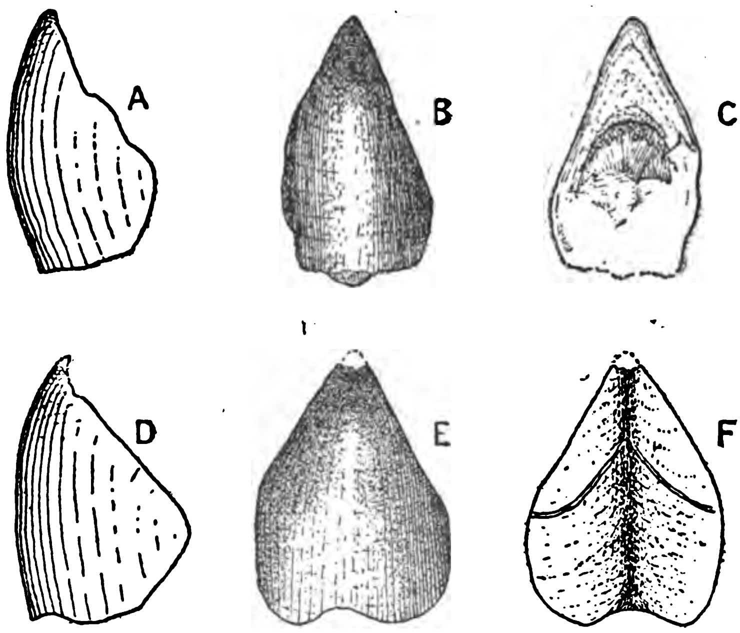
Lindström is undoubtedly correct in stating that the V- or chevron-shaped space at the posterior end of these plates is the overlapping area of the valves, and he considers it homologous with the linear area on the inside posterior end of recent Chiton plates, and "seems hardly to have received all the attention it deserves."

I have termed this the area of imbrication, and fail to see how it can be regarded as an area of insertion, a term used by several Writers. It must be borne in mind that the insertion areas proper are found on the cephalic and anal plates of recent and most fossil Chitons, being extensions of the articulimentum, as are the apophyses likewise. Salter remarks† that the inflected portion of each plate below the apex diminishes in size according as the plates are more closely pressed against each other.

* Quart. Journ. Geol. Soc., 1859, XV, t. 16, f. 25, 26.
† Quart. Journ. Geol. Soc., 1847, III, p. 50.

The plates from Yass probably belong to the intermediate series, and are all tegmental, there being no articulimental portion here. A perusal of Salter's interesting remarks on *Helminthochiton* will leave very little doubt as to the intermediate position of the present pieces, or as he terms similar ones, dorsal.

The plates of *Chelodes* were probably ranged in linear series like those of *Helminthochiton*, for I think we may conclude that such was the case in the latter, judging from the very slightly displaced position of those originally figured* by De Koninck. Woodward now believes *Solenocaris*, Young and Young, to be a Chiton, and has figured a similar line of plates†. Furthermore, if the inflected area below the apex of each plate diminishes with close adpressure of the plates against one another, as Salter says it does, then it follows that the plates of *Chelodes* must have reposed in a more or less separate state from one another, in the girdle or zona of the mantle.



To these interesting plates I purpose applying the name of *Chelodes calceoloides*. They were obtained by Mr. Charles Cullen, at Portion No. 1 of 635 acres, Parish of Derringullen, County of King.

* Bull. Acad. R. Belgique, 1857, III (2), t. 1.
† Geol. Mag., 1885, II (3), p. 357.

XV.—The Auriferous Beach Sands of the Esk River and Jerusalem Creek, in the Parish of Esk, County Richmond, New South Wales, by J. E. CARNE, F.G.S., Geological Surveyor.

I.—Previous Mention.

IN 1894, Mr. Geological Surveyor Stonier reported on the auriferous sands near the Evans River, about eight miles north of Jerusalem Creek, and briefly alluded to the locality now under consideration.*

In 1880, Mr. E. F. Pittman, A.R.S.M., examined the auriferous beach-sands between the Richmond and Tweed Rivers.†

In 1889, Mr. C. S. Wilkinson, late Government Geologist, described those near the Richmond Heads, as well as the auriferous basalt of the same locality.‡

In 1892, Mr. J. C. H. Mingaye, F.C.S., Analyst to the Department of Mines, read a paper "On the occurrence of gold, platinum, and tin in the beach-sands of the Richmond River District."§

A detailed description of the methods of working the beach-sand will be found in the Annual Report of the Department of Mines for 1895.

II.—Physical Geography.

The Parish of Esk, with the exception of its north-west corner, where the dividing range between the Clarence and Richmond coast waters crosses it, consists of a tract of level forest land, merging gradually into broad, marshy, almost treeless flats, along the sea-coast which forms its eastern border. It is difficult to define the boundary between the sea and land-made deposits, because the loose sand derived from the weathering of the massive sandstone of the adjacent high lands on the west, is mingled with the sea-worn sand which has been drifted inland by the action of the wind. It is clear, however, that numerous shallow inlets of the sea penetrated at one time well inland towards the dividing range; but there is not sufficient ground for the belief entertained by some of the miners, that the foot of the present range represents the original shore-line prior to the deposition of the auriferous sands. Between the range and the coast (a distance of about nine miles due west from McAuley's Lead), the sandstone bed-rock can be seen *in situ* on the low ridges and in road cuttings; the most eastern outcrop noticed being about three miles east of the Halfway House.

* Ann. Rept. Dept. Mines and Agric. N.S. Wales for 1894 [1895], pp. 129-131.
† Ann. Rept. Dept. Mines N.S. Wales for 1880 [1881], p. 245.
‡ Ann. Rept. Dept. Mines N.S. Wales for 1889 [1890], p. 203.
§ Journ. R. Soc. N.S. Wales for 1892 [1893], XXVI, pp. 368-370.

The coastal country between the Clarence River and Jerusalem Creek Heads, is enclosed on the west, in semi-circular form, by the dividing range, as far south as Tobbimoble; and thence easterly by high lands to the Clarence Heads. The bay-like appearance of this low area, partially enclosed by a rim of high land, doubtless gave rise to the belief above stated as to its marine origin.

III.—Geological Features.

The geological formation represented in the coast country between the Clarence and Richmond Rivers, consist almost entirely of Clarence (Triassic) Coal-Measures. Mr. Stonier describes a small outlier of slate at Bullock Creek, between Jerusalem Creek and the Evans River, as probably of Lower Carboniferous age; but this classification is based solely on stratigraphical position.

About half-a-mile south of Evans River Heads the coast section exposes a massive escarpment of sandstone with conspicuous current bedding, overlying sandy shales containing a seam of inferior coal, about one foot thick, just above high-water mark. The high downs of this locality are formed of the above sandstone, large bosses of which are seen outcropping at intervals. The highest beds of the dividing range west of the Esk River, also consist of the same massive sandstone; these form the middle beds of the Clarence Coal-Measures, and are regarded as the geological equivalent of the Hawkesbury Series.

Igneous rocks are represented by a felsitic dyke which intrudes the Coal Measures just south of the Evans River. From the strike of this dyke it is extremely probable that the very reef on which the ill-fated "S.S. Cahors" was wrecked (about two miles south-easterly), is a hard boss of the same rock which has resisted the wearing action of the sea more successfully than the enclosing shales and sandstones.

On the dividing range at Tobbimoble and near Double-duke Peak, south-west of the Esk River, two small isolated patches of basalt have so far been recorded. These are of special interest as they indicate a considerable southern extension of the volcanic flow so largely represented north of the Richmond River.

IV. Discovery of Gold in the Beach-sands.

According to Mr. D. Munro of Ballina—who is well known as a most observant and careful recorder of geological and other phenomena—gold in payable quantity was first discovered in beach-sand in New South Wales, at Shaw's Bay near the North Head of the Richmond River, by John Sinclair in March, 1870, who obtained twelve ounces of gold in a fortnight. The publication of this return caused a rush, and drew New Zealand beach-miners to the spot with the appliances which experience had proved most suitable under similar conditions on the West Coast of the South Island of that Colony. Though thirty years have elapsed since the commencement of beach-mining in New Zealand, blanket, carpet, or cocoa-nut matting covered

tables have not been superseded. Dredges have been tried on the beaches unsuccessfully. Little hope of success with dredges is expected until the principle adopted by the miners is used in connection therewith.*

From the date of Sinclair's discovery to the present time, the beaches of the North Coast have given employment to many. Periodically large numbers find remunerative work for several months in the year. Mining on the present beaches will, however, always be of an intermittent character, because of its dependence upon the occurrence of south-easterly gales to break up fresh portions of the terrace of black sand rock, which is exposed for miles along the coast just beneath the loose sand-dunes, and to concentrate the heavier particles on the surface of the beaches into what are locally called "sniggers". The lower portions of the loose white sand-dunes fringing the coast also contain particles of previously liberated gold, which help to enrich the concentrates accumulated in workable form during stormy conditions.

Mr. Munro states that the richest patches recorded in the early workings were found on the southern side of the headlands, which is in conformity with the greater force exerted at such points by the prevailing winds, viz. south-east. The localities recorded by the same authority as being specially distinguished by their original richness are Tallow Beach, south of Byron Bay; Seven Mile Beach, south of Broken Head; Black Rock Beach; and the beach south of Evans Head. From these localities gold valued up to £800 per man were obtained in periods ranging from six to nine months.

For a considerable time past little actual beach-mining has been done owing to the absence of any gales of consequence. North of Jerusalem Creek auriferous deposits have been worked some distance back from the beach on areas of some elevation above sea-level. As the occurrence of the auriferous sands under such conditions in this locality has formed the subject of a special report by Mr. Stonier (already quoted), the present detailed description will be restricted to the more recent discoveries in the flat lands further south.

M'Auley's "Lead."† In March 1895, Messrs. Alexander and Angus M'Auley discovered the lead which bears their name, and to them belongs the credit of the first discovery of payable gold in the "black rock" at a distance from the present beach, but not, as is frequently stated, for the first discovery of gold inland from the sea-line.

The lead occurs on the east face of a low, narrow sand-dune, which trends parallel with the coast line for several miles. For a long distance the lead keeps uniformly on the eastern face, but near the north end it underlies it. Its trend, so far as traced, is about north and south, and the distance from the coast about three-quarters of a mile.

* Papers and Reports relating to Mining in New Zealand, 1893, p. 120.

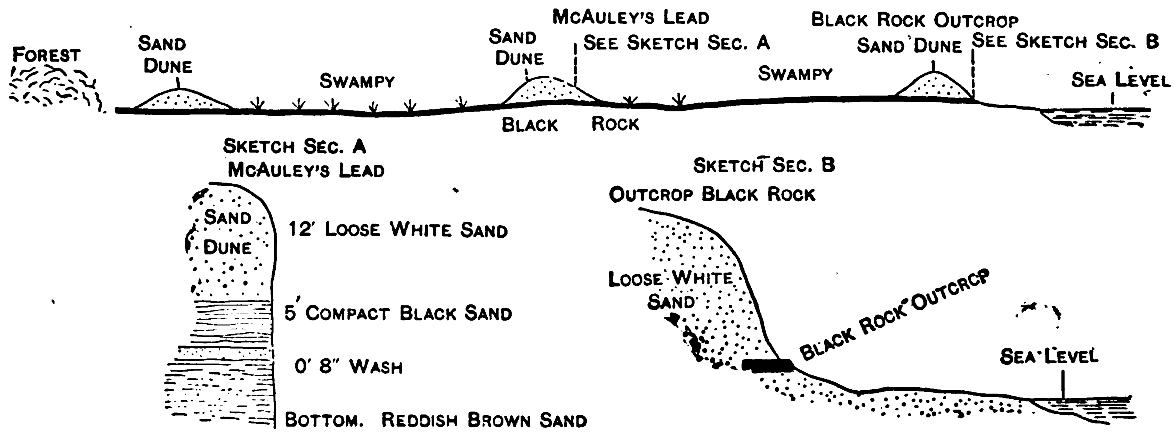
† The term "lead" is adopted in this report because of its local use; the auriferous wash, however, has been deposited by the action of the sea on an earlier shore-line, and not by a fluviatile stream.

The sand-dunes—several of which occur between the coast and the Esk River—are about three hundred feet wide, and from ten to fifteen feet above the general level. Locally they are known as "terraces"; this term, however, has a local significance, differing from the ordinarily accepted meaning of the term in mining. About M'Auley's Lead and Jerusalem Creek, it simply denotes long, narrow windrows of loose white sand parallel to each other and the coast; and separated by areas of low marshy ground covered with stunted vegetation, chiefly speargrass.

The "black rock" cropping out along the present coast line on a uniformly level horizon indicates a prior extension of the swampy conditions seawards, and a subsequent encroachment of the sea. But whether the slight elevation of the surface of the black rock represents an elevation of the land or depression of the sea-bed, or simply an accumulation of sand thrown up by stormy conditions, sufficient data is not yet to hand to enable a determination being arrived at.

The following rough section of the country between the sea-coast and the edge of the forest land west of M'Auley's Lead, will give a fair idea of the so-called terraces, and possibly suggest a mode of formation. If the most western dune or terrace be regarded as approximately the position of an earlier shore line of a broad, shallow estuary, the middle terrace may be regarded as the probable site of a sand-bar which gradually shut off the sea-water; the land drainage and rainfall into the intervening area would gradually tend to render the impounded shallow sea-water brackish, and subsequently fresh; whilst the suspended matter would form nutriment for swamp vegetation, the decay of which has coloured all the underlying beds, so far as tested, to a more or less degree of blackness.

A repetition of similar conditions would account for any number of dunes or "bars" to suit the circumstances.



One of the small sections represents the outcrop of the "black rock" on the coast, along which it forms a most marked feature; and the other the nature of the sinking at M'Auley's Prospecting Claim; the latter being to scale. At this point, however, the over-burden of loose white sand is exceptionally heavy, as the lead here is under the terrace.

A short distance north from M'Auley's the terrace takes a turn to the eastward, and swampy conditions prevail in the direct line of strike. At this point the lead has been lost, and a considerable distance intervenes between its north end and the next nearest workings which are known as Coolgardie. The connected line of claims which form M'Auley's Lead proper extends for a distance of about two miles.

Since M'Auley's discovery the terraces have been followed as guides in prospecting; but it is doubtful whether their present positions can always be regarded as having been permanent since the first accumulation of the loose sand forming them, for the prevailing wind must tend to move them forward in the direction of its course. This objection applies only to the loose sand above the compact or swampy conditions, in which the inequalities would be permanent. The bend to the eastward, north of M'Auley's Claim, may be due to the protection afforded by the higher sand-dunes on the shore line opposite to, and a little south of, this point, which intercept and modify the force of the wind; whilst the unprotected terrace further south would tend to move bodily in a more or less straight line. Hence, there is every reason to expect to find in the level swampy areas between the terraces other old shore lines twelve feet deep. At this level the compact black sand—locally identified as the "black rock"—is met with, and five feet below its surface the auriferous layer is reached. Underlying the wash is a layer of reddish-brown sand, which is regarded as bottom. At the west side or back of the lead the auriferous layer forms but a thin streak, which thickens gradually on the underlay seawards. Its richness decreases proportionately with the thickening, and the overburden becomes correspondingly heavier. Hence, the width of the workings represents the payable limit of the wash following the underlay. This fact holds good for the whole lead, the workable width of which, under present conditions, varies from about fourteen feet to thirty feet.

The richest portion of the wash lies well up on the sloping bottom of the lead, just as do the "sniggers" of the present beaches after south-easterly gales. The gradual cessation of the gales and recession of the waves tend to draw off the lighter particles down the sloping surface of the beach, leaving the heavier stranded beyond the reach of normal waves, Nature thus performing on a gigantic scale the panning of the miner.

In a number of claims—Williams and Party's, for instance—two layers of auriferous sand occur, separated by about three inches of barren sand, the auriferous layers in this instance being six inches and ten inches thick. The intervening barren sand increases in thickness in some claims—as at Keats and Party's—to about two feet.

About twelve inches above the top of the black sand is a layer of varying thickness known as the "blue seam," which carries colours of gold, this colour of the layer being due to the distribution of black sand particles through the pure white. This "seam" represents very probably æolian concentration on the surface of the compact black rock. The concentrating action of the wind by removal of the lighter particles of quartz sand is seen to advantage any windy day on the sea beaches; at a distance the wind-borne particles have the appearance of dust. In this way large areas of beach surface, covered with a thin superficial layer of the heavy black sand grains, have been completely sifted of the lighter quartz particles which were left entangled by the waves.

In the black rock above the wash very black thin bands occur at intervals, one very characteristic one (about one inch thick) just above the wash. These are exceedingly hard, most likely owing to the precipitation of an iron salt by organic matter.

In October last there were but four claims at work north of M'Auley's Lead. In the most northern—Wilson and Bourke's—the stripping is very heavy; about sixteen inches of wash is said to underlie it.

As before stated, north of this point a break in the lead occurs, extending for at least a mile. Up to this point the "terrace" has run a true course nearly north and south; here it takes an easterly bend. If, as there is reason to believe, the lead represents an earlier shore line, a sinuous bend partly round a projection seawards, or following an inshore encroachment, may naturally be expected, which may account for the loss of the lead at the north end of M'Auley's, irrespective of the contour of the terrace; on the other hand, the lead may yet be found on its course under the swampy land, and ultimately connect with the Coolgardie lead, which lies in the same general direction.

South from M'Auley's Claim the lead, with few exceptions, is being worked in a continuous line of claims for about one mile and a half. The richest portion, however, lies north towards the prospecting claim.

Prospecting has been extended for a considerable distance south of the most southern workings but without success, gold being obtainable, but not in payable proportion. In this direction the wash shows a considerable thickening, accompanied by a corresponding depreciation in richness. In M'Auley Brothers' Claim, at the extreme south end, the auriferous layer is three feet six inches thick and the approximate width twenty feet. An attempt was being made to work about two feet of this wash.

Coolgardie Lead.—This lead is situated on the west side of Jerusalem Creek. Three claims only were at work, but active prospecting was proceeding between it and the mouth of the creek. A number of claims have already been worked out north of the above lead.

The most interesting feature about the Jerusalem Creek mines, and one of hopeful import to the field, is that several distinct runs of gold-bearing sand have been proved in the swampy flats as well as in the terrace. In the swampy ground the sinking is from nine feet to twelve feet. The runs of wash vary in thickness from one foot to two feet by a width of about twelve feet. Water stands within about three feet from the surface.

Close to the head of Jerusalem Creek the gold is obtained from about two feet of white sand just above the black rock, the best yield being from a seam about three inches thick directly above the latter. The underlying black rock has been tested to a depth of twelve feet, but nothing beyond colours was obtained; this, however, appears to have been a single test.

North from Jerusalem Creek the coast country loses its level character, and changes from marshy land traversed by low parallel sand-dunes to very undulating country, covered with high dunes irregularly disposed. Between the sand hills fresh water channels trend from the adjacent high lands in the west. At intervals large basin-shaped depressions occur, also filled with fresh water. Along the shore line high narrow sand-dunes extend, the leeside of which affords capital camping ground for the itinerant miners who periodically visit the locality after stormy weather to work the "sniggers" or concentrates formed by the action of the high waves. In October, however, this locality was practically deserted owing to the superior attractions of M'Auley's Lead and the absence of gales.

All the workings on the high-levels back from the beach in this neighbourhood have been in the loose white sand.

During my inspection small quantities were selected from the tailing heaps of at least two-thirds of the claims on M'Auley's Lead for the purpose of obtaining, by assay, a general idea of the loss in the first part of the treatment. In like manner small quantities of the concentrates, after amalgamation, were secured; from the general average of these samples the following results were obtained under the supervision of Mr. J. C. H. Mingaye, F.C.S., Analyst and Assayer to the Department:—

[4138] Mixed tailings from about two-thirds of M'Auley's Lead Claims—

Gold	2 dwts. 14 grs. per ton.
Silver	1 dwt. 7 " "
Metallic tin	0·05 per cent.

No platinum or platinoid metals detected.

[4139] Concentrates from about two-thirds of M'Auley's Lead Claims, after amalgamation—

Gold	2 ozs.	19 dwts.	3 grs.	per ton.
Platinum	0 „	18 „	17 „	„
Iridosmine		under	15 „	„ .
Metallic tin	5·12 per cent.			

[4270] Tailings from Hammond, Dowling, and Party's Claim—

Gold	3 dwts.	19 grs.	per ton
Silver	3 „	19 „	„
No platinum or platinoid metals detected.			

[4269] Concentrates from Hammond, Dowling, and Party's Claim, after passing three times over amalgam plates—

*Gold	15 ozs.	1 dwt.	12 grs.	per ton.
Platinum	2 „	18 dwts.	3 „	„
Iridosmine	0 „	17 „	7 „	„
Metallic tin	28·52 per cent.			

The following assay results, obtained in the Department's Laboratory †, are quoted to show the extent to which concentration, on a small scale, has been carried on as regards the metals other than gold, and the tin oxide. Unfortunately, these returns afford no data of value, as particulars are not available as to the quantities of wash operated on.

With the exception of No. 1251, these samples were, presumably, concentrated in the ordinary manner by frequent passage over carpet-covered tables. The exception was the result of manipulation in a small experimental machine constructed by a Mr. R. Young, but nothing is known of the principle.

[245] Concentrated beach sand from Ballina—

Platinum	428 ozs.	9 dwts.	4 grs.	per ton.
Iridium	26 „	16 „	16 „	„
Osmiridium	161 „	13 „	20 „	„
Other platinoid metals	2 „	16 „	11 „	„
Gold	2 „	19 „	12 „	„

[1251] Beach sand from the Richmond River district, concentrated by Mr. R. Young—

‡Gold	70 ozs.	4 dwts.	16 grs.	per ton.
Platinum	36 „	5 „	4 „	„
Iridium	8 „	6 „	14 „	„
Iridosmine	6 „	0 „	18 „	„
Other platinoid metals	4 „	8 „	2 „	„
Metallic tin	25·7 per cent.			

[2690] Concentrated beach sand, containing some amalgam from the Richmond River district—

Gold	100 ozs.	18 dwts.	7 grs.	per ton.
Platinum	68 „	0 „	4 „	„
Osmiridium	8 „	18 „	23 „	„
Iridium and other platinoid metals	2 „	1 „	19 „	„
Metallic tin	28·96 per cent.			

* Chiefly from amalgam which escaped from the plates.

† Ann. Rept. Dept. Mines and Agric. N. S. Wales for 1894 [1895], p. 57.

‡ In this case it is known that none of the gold got had been removed by amalgamation before concentration.

[2879] Concentrates from J. Ware's Claim, Richmond River District—

Platinum	129 ozs.	9 dwts.	16 grs.	per ton.
Osmiridium	58 „	0 „	7 „	„
Iridium and other platinoid metals	5 „	0 „	7 „	„
Gold	0 „	9 „	11 „	„

[3499] Concentrated beach sand from between Richmond River Heads and Byron Bay—

Platinum	7 ozs.	13 dwts.	22 grs.	per ton.
Osmiridium	1 „	6 „	0 „	„
Other platinoid metals	0 „	3 „	6 „	„
Gold	0 „	9 „	18 „	„
Metallic tin	15·82 per cent.			

Composition and characteristics of the wash.—High specific gravity, fineness of component particles, and colour, are the physical characteristics which immediately arrest attention.

The specific gravity of a sample of the wash from M'Auley's Claim carefully determined by Mr. Mingaye was 4·42, that of the average concentrates of the lead after amalgamation 4·22.

An attempt was made to estimate the proportion of quartz sand in the natural wash by means of a gravity solution, viz., borotungstate of cadmium which has a density of 3·28. With the exception of a few grains which remained in suspension, the whole of the sample settled at the bottom of the tube; from which it may be inferred that the proportion of quartz is very slight, as indicated by the high specific gravity (4.42).

On warming a little of the wash with distilled water the solution gave an acid reaction with litmus paper. On roasting at a low heat in the open, the organic matter and colouring were readily burnt off, which opens up the question as to the relative advantages of roasting and solution. To effect thorough combustion of the organic matter by roasting open hearths or plates lightly spread charges and frequent raking will be necessary. The two processes are equally effective as far as cleansing the sand grains is concerned; roasting, however, removes the peaty particles which would remain practically untouched in the solution; this does not, however, affect the equal value of the solution process, as the peaty fragments would not interfere with amalgamation. The question therefore, resolves itself entirely into one of relative cost. After roasting in the open it was found that the major portion of the titanic iron could be removed by magnetic separation. Briefly stated the wash is composed chiefly of small zircons—mostly uncoloured—ilmenite (titanic iron), quartz, garnets, tinstone, and varying proportions of gold, platinum and platinoid metals. The hardness (7·5) and highly crystalline character of the zircon sand suggests the possibility of its utilization for the preparation of an improved variety of sand-paper.

The fineness of the component particles of the wash will be easiest comprehended from the results achieved in sizing tests, which are given in the following abstract:—

Sizing tests.

Locality.	Nature of Material.	Weight of Sample.	No. 1 screen. 900 holes to sq. inch.	No. 2 screen. 3,000 holes to sq. inch.	No. 3 screen. 8,100 holes to sq. inch.	Passed through No. 3 screen.	Remarks.
			Remaining.	Remaining.	Remaining.		
M'Auley Bros. Claim	Wash (specific gravity, 4·42)	1,734 gr.	....	(a) 17 gr.	709 gr.	1,015 gr.	A little peaty matter was previously extracted from this sample by No. 1 screen. (a) Lost 2·82 gr. on ignition.
M'Auley's Lead (Assay No. 4,139)*	Average concentrates after amalgamation. From two-thirds of the claims on the lead	2,000 „	....	58 „	425 „	1,517 „	On No. 1 screen, a few peaty particles. On No. 2 screen, chiefly quartz sand. On No. 3 screen, a few colours of free gold visible.
Hammond, Dowling, and Party's Claim, M'Auley's lead (Assay No. 4,269)*	Concentrates after passing three times over copper plates	1,000 „	....	....	129 „	871 „	No. 3 screen—Numerous gold particles on this screen. No. 3 screen—Practically all tinstone passed through.
O'Dwyer's Claim, do.........	Platinum concentrates.........	653 „	....	3 gr.	39 „	611 „	No. 2 screen—Amalgam. No. 3 screen—Platinum and gold showing on this screen.
Shellharbour, south of Wollongong (Assay No. 4,327)†	Concentrates	1,298 „	36·5 gr.	35 „	109 „	1,117·5 „	No. 1 screen—7½ per cent. of metallic iron scale; balance, ferric and titanic oxides. No. 2 screen—Chiefly quartz, mag. iron, ferric oxide, and ilmenite. No. 3 screen—Quartz, colourless zircon, mag. and ferric oxides.
Richmond River District	Concentrated platinum (clean sample)	74 „	....	....	1 „	73 „	No. 3 screenings—Amalgamated gold and a little ilmenite.

* For results of these assays see page 78 *antea*.

† This sample yielded:
- Platinum...... 30 oz. 10 dwt. 18 gr. per ton.
- Gold .... 1 „ 15 „ 22 „ „
- Tin .... 49·01 per cent.

Payable leads beneath those at present worked.—So far as could be ascertained very few attempts have been made to test the sandbeds beneath the present wash level. In some of the very few test holes below the bottom of the leads colours of gold have been found. It appears very probable that deeper leads exist, but the possibility of working below a stripping level is not very bright, unless the yield be high. The presence of permanent water, with impossible drainage and porous and treacherous ground, requiring powerful pumping machinery and close timbering or boxing, would render working very costly.

Derivation of the gem sand and associated metals and metallic minerals.—As might be expected, considerable diversity of opinion exists as to the source of the precious metals in the sands of the north coast beaches. Some regard the adjacent coast ranges as the original repository; others surmise the existence of auriferous reefs beneath the sea parallel with the coast line; whilst others, regardless alike of distance and opposing currents, look even so far as the West Coast of New Zealand, where similar auriferous sands occur. The theory of precipitation from sea water is also not without its advocates.

For the sake of comparison it is interesting to note Sir Julius von Haast's description of the alluvial workings on the West Coast of New Zealand. The earliest found and most elevated of the drifts rest on terraces composed of Marine Tertiary strata where they have escaped denudation by the streams descending from the mountains. The second group of gold diggings are those in the beds and alluvial terraces of streams which intersect the first mentioned leads. Third, the beach terraces which extend to an altitude of two hundred and twenty feet, and mark several changes in the level of the shore line within a comparatively recent geological period. In this group also must be classed the gold deposits formed on the present coast line by the action of the surf and currents, which distribute along the shore the gold brought down by the streams.* As detailed geological survey proceeds, the interesting problem of origin presented by the north coast auriferous beaches will doubtless receive practical demonstration; in the meantime the following possible sources may be discussed:—

(*a*) The underlying Siluro-Devonian rocks.

(*b*) The Clarence Coal-Measures, particularly the basal and middle beds of the Series.

(*c*) Early drainage channels, represented by drifts under basalt.

(*d*) The auriferous (?) basalt at the Richmond River Heads.

(*e*) Present drainage channels from the eastern margin of the auriferous and stanniferous rocks of New England.

* Mining Statements and Goldfield Reports, New Zealand, 1893, p. 156 By Authority.

In considering the above suggested sources it is essential that the enormous spread of the auriferous sands along the coast should be kept prominently in view. From near the Queensland Border to Port Macquarie at least these sands have been worked; and even as far south as Shellharbour, south of Wollongong, similar sands occur, and have received a little attention. The distance between the extreme points mentioned is about five hundred miles. In considering the probability of any restricted source, such as the Ballina basalt, it must also be remembered that the trend of the coast current is southerly.

The break in the continuity of the auriferous sand along the coast, between the main southern (Shellharbour) and the nearest northern (Port Macquarie), will, perhaps, eventually be accounted for by the difference between the geological formations of the watershed between these points and those opposite the auriferous beaches.

(*a*) The underlying Siluro-Devonian rocks developed on the north coast, between Broken Bay, near Ballina and Sutherland Point, near the Tweed River Heads, contains numerous quartz reefs. In a few instances assays up to several pennyweights of gold per ton have been obtained from the most favourable; but the average results have not exceeded two pennyweights per ton. Mr. E. F. Pittman, after an examination of the auriferous beaches between the Richmond and Tweed Rivers, came to the conclusion in the year 1880 that the black sand and gold evidently come from a drift (underneath the basalt) derived from the underlying older rocks (Siluro-Devonian).*

The basalt referred to touches the coast about Ballina at the Richmond Heads, where it overlies the Clarence Coal-Measures, hence any drifts directly underlying it having the above deviation must have been transported from the Siluro-Devonian area on the north. The drift becomes additionally important if, instead of restricting its source to the underlying rocks, we regard it as evidence of exclusive channels which, prior to the basalt outflow, drained from the high auriferous and stanniferous areas to the west. This extension of the source of the drift would account for the large proportion of the gem sand and the tinstone which are invariably associated with the gold and platinum metals in the beach sands; neither of which could be reasonably assigned wholly to the Siluro-Devonian sedimentary rocks.

(*b*) The Clarence Coal-Measures form the surface rocks along the coast from a little north of Ballina to nearly opposite Solitary Island, a distance of about eighty

* *Loc. cit.*, p. 245.

miles south. The auriferous character of these measures is based upon the discovery of gold in minute specks in the Hawkesbury Sandstone (which is regarded as the equivalent of the middle beds of the above measures) at North Shore and Govett's Leap, by the Rev. W. B. Clarke,* and recently by Professor Liversidge in the same beds at Pyrmont, and in the overlying Wianamatta shales in the University Grounds, Sydney†. The basal conglomerate of the Clarence Coal-Measures, so far as is known, has not been tested. This bed has an extensive outcrop along the western margin of the coal basin, where a thickness of several hundred feet rests directly on the auriferous Siluro-Devonian slates and sandstones of the eastern falls of the New England Tableland. Where exposed in creek sections the conglomerate and intercalated coarse grits are generally very friable; frequently quartz pebbles are abundant, the bulk, however, being slate and granite. Considering the nearness of the Dalmorton, Mann River, and Solferino reefs, and the junction of the stanniferous granite, it is reasonable to expect to find at least traces of gold, tin, and gem stones in a conglomerate formed from the wearing down of such rocks. Through the kindness of Mr. W. J. Mulligan, of O. B. X. Creek, about twenty miles from Grafton, I have been able to test, by panning off, about fifty pounds of this conglomerate; but, contrary to expectation, none of the above-mentioned minerals were detected. The test, however, can only be regarded as a superficial one. Though gold has been determined in the Hawkesbury Series, there is no record of platinum ever having been detached.

The basal beds of the Clarence Measures have an additional interest inasmuch as beds of similar age and geological horizon have recently identified by Mr. E. F. Pittman, Government Geologist, as containing artesian water at Moree.

(*c*) *Drifts under basalt.*—This possible source has already been alluded to under section (*a*). Basalt is extensively developed as a surface rock between Ballina and Casino; thence north-westerly up the channel of the Richmond River to Roseberry Station, and from there north-easterly to the coast at Point Danger.

Another outcrop trends north from Casino to Fairy Mount, and from there north-east to the Valley of the Tweed, where it joins the first-mentioned.

The isolated patches of basalt at Tobbimoble, and near Doubleduke Peak on the dividing range of the Clarence and Richmond coast waters afford indisputable evidence of a southern extension of the Richmond basalt sheet, or of a similar flow now almost entirely removed.

* Southern Goldfields, pp. 44 and 244 (8vo). Sydney, 1860.
† Journ. R. Soc. N. S. Wales, 1894, XXVIII, pp. 185-8.

Under the Tobbimoble basalt patch, which is now but ten to fifteen feet thick, resting on Hawkesbury Sandstone, quartz, pebbly, and granular drift occur, which has been prospected by three or more shafts, a little gold being obtained. From selected samples fine colours of gold and a little of the characteristic gem sand of the beach wash were obtained. Tobbimoble lies about ten miles south-west of M'Auley's Lead.

The extensive basalt flows of the Richmond and Tweed Districts in all probability filled up the pre-existing drainage system from the western tablelands, and this would, as before stated, account for the composition of the beach sands, formed from denudation of the old channel debris.

(*d*). *Basalt as a Source of the Gold.*—According to Mr. Munro, gold was first reported in decomposed basalt at Black Head, near the town of Ballina, in February, 1888. The only other record of the occurrence of gold in basalt ascertainable is that recently announced by Mr. J. Collett Moulden, A.R.S.M., from Kangaroo Island off the south coast of South Australia.* Professor Tate in an editorial note states that the basalt referred to occurs as an intrusion in mica schist. The specimen microscopically examined by Mr. Moulden contained a small speck of gold embedded in it which might have been caught up from a reef in the intruded schist.

The late Government Geologist, Mr. C. S. Wilkinson, described the Ballina occurrence in the following terms:—"The town of Ballina, which is immediately within the river entrance from the ocean, is situated on the flat; but the north head of the entrance consists of a small hill of dense black basalt and blown sand. About half a mile further north is the Black Rock (Head), a perpendicular cliff thirty feet high, facing the ocean, and composed at the base of hard dense basalt, then a bed four to ten feet thick of scoriaceous volcanic agglomerate, overlaid by fifteen to twenty feet of hard dense columnar basalt; above this is about thirty feet of soft decomposed laminated basalt.

"Mr. Munro informed me that from the lower agglomerate bed several parcels had been treated in Sydney—one of over 3 tons yielding at the rate of 2 dwt. 10 gr. of gold per ton, and another of 19 cwt. yielding 18 dwt. 11 gr. of gold per ton; a total of about 7 tons 17 cwt. treated gave an average yield of 12 dwt. per ton. These beds have a slight dip inland, and could be easily worked. There is no doubt that the gold and platinum in the sand and gravel on the beach, which has for years past been worked to the north and south of Black Rock, have been derived from the denudation of the basalt, the rippling action of the ocean surf tending to throw back the gold with the black sand and shingle drift about high-water level."†

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* Trans. R. Soc. S. Austr., 1895, Vol. XIX, Pt. I, pp. 71-72.

† Ann. Rept. Dept. Mines N.S. Wales for 1889, p. 203.

Mr. Wilkinson personally selected samples from the 4-ft. bed in Jones' shaft—from the top 1-ft. layer of the lower 8-ft. bed, from the top bed thirty feet thick and from lower 7-ft. level—all at Black Rock. In only one of these samples was the Departmental Analyst, Mr. Mingaye, able to detect even a trace of gold.

Mr. Wilkinson also selected samples from the same basalt sheet near Lismore; in none, however, was gold detected.

Whilst recently at Ballina I also selected a sample from the agglomerate, and later on Mr. Munro forwarded a larger sample. In both instances care was taken to break away the seaworn face, and to take only the freshly exposed material. Large duplicate assays and panning tests failed to detect the presence of gold in either sample.

The value of the discovery is greatly discounted by the conflict between the numerous fire assay results and those obtained by mechanical treatment from bulk parcels, a statement of which, through the kindness of Mr. Munro, is here given.

Statement of Crushings of Basalt from Black Rock, Ballina.

Where treated.					Yield per ton.			Remarks.
	tons	cwt.	qrs.	lb.	oz.	dwt.	grs.	
Sydney Mint	0	17	1	16	0	15	6	From sea-face, lower seam.
Parke and Lacy 2	3	8	0	10	0	2	12	,, ,, ,,
,, ,, 2	1	18	3	15	0	12	13	From drive in lower seam.
,, ,, 3	0	19	1	3	0	18	11	,, ,, ,, 20 to 30 ft.
,, ,, 3	0	14	1	16	0	9	18	From top or surface seam.

The above parcels were despatched in three lots at different dates in 1888.

Were it not for the yields from the two parcels obtained from drives in the lower seam (one of which is stated to have been from twenty to thirty feet in length), the discrepancy between the assay and bulk crushing results might be accounted for by the accidental occurrence of gold in the exposed scoriaceous agglomerate face at the foot of the Black Rock, the vesicular cavities of which would act as small riffle holes as the auriferous sand of the coast is dashed against it by the wash of the waves which continuously reach it, save at low tide. That gold-sands have been perpetually dashed against this bed is undoubted, because of the occurrence of one of the richest patches of beach-sand just on the north side of the Black Rock.

The presence of gold in the decomposed basalt forming the soil on the top of the cliff just below the lighthouse (where the discovery was first made) does not weaken the above solution of the question, because the wind-blown sand mentioned by Mr. Wilkinson has at one time extended over the top of the basalt at this point; a little of it even now remains. As it was drifted away by the wind a few fine gold particles would remain on the surface of the decomposing basalt, and would slip into sun-cracks and joints, and thus account for the surface prospects obtained. It is unaccountable why such favourable prospects obtained from bulk samples have not been followed up.

The gemsand and tinstone, which are such uniformally persistent associates of the gold and platinum of the beach-sands, can hardly have been derived from the basalt, even if the gold was. A quantity of the crushed basalt was carefully panned, but no trace of any enclosed gem-stones could be seen under the microscope; even if these had been present in quantity their presence would, perhaps, be best accounted for by accidental engulfment in a basalt overflow.

(*e*) *Present drainage-channels from the eastern margin of the auriferous and stanniferous rocks of the New England Table-land.*—These channels have a precipitous watershed from the above formations, and short courses to the ocean. They are very subject to flooding in rainy seasons, the currents at such times being swift and powerful. The lower stretches of these rivers have little fall, and here the heavier burdens from the precipitous upper reaches are dropped, whilst only the finest particles are swept on to the sea.

Where the watershed is formed of rocks differing from those mentioned above (as west of Sydney, where the Hawkesbury Series, and the Permo-Carboniferous Measures form the high lands) the characteristic auriferous sand is absent from the coast beaches.

Taking all these facts into consideration, it seems most probable that the earlier drainage channels (represented by the drifts under the basalt flows), and the present surface streams, have been and are the feeders of the auriferous beaches. The early drainage channels probably first began the work of transporting the sand to the sea, which is now being carried on by the present drainage system. Owing to the extreme fineness of the particles the powerful currents of these old torrential rivers—like the present—were able to overcome the high gravity of the component minerals, and sweep them on to the ocean, where they encountered an opposing current and the shoreward sweep of the waves. Since the basalt flow filled up these early rivers, and turned the waters into new channels, atmospheric denudation has been steadily wearing away the volcanic cover, and bringing the imprisoned drifts again within the transporting influence of rain and stream to the further enrichment of the beaches.

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PLATE VI.

Syringothyris exsuperans, *De Koninck, sp.*

Fig. 1. Conjoined ventral and dorsal valves, showing the high and wide area, small channelled and incurved umbo, and open delthyrium in the former; and the fold and costæ in the latter. Greenhills.

Fig. 2. Similar specimen, showing the slits left by the dental plates, and the arched "transverse plate." Greenhills.

Fig. 3. Internal cast, somewhat crushed and distorted, showing the slits left by the decomposition of the dental plates, with a wider arched "transverse plate" in the ventral valve; and the fold with the impression of the septum and lateral costæ in the dorsal valve. Parish of St. Aubin.

Fig. 4. Reverse of Fig. 3, exhibiting the wide and inner slits of the dental plates, muscular impressions, and coarse costæ of the ventral valve.

Fig. 5. Internal cast of the ventral valve of a smaller individual, displaying the slits of the dental plates, area, and delthyrium. Parish of St. Aubin.

Fig. 6. The area of Fig. 5.

Fig. 7. Punctate shell structure, seen on the lateral slopes of another specimen. Greenhills.

Drawn from nature by Mr. P. T. Hammond.

3

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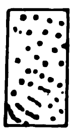

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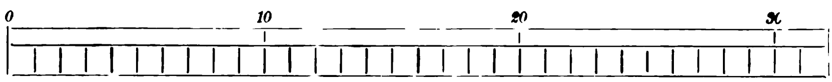
P. T. Hammond, del. Heliotype.

PLATE VII.

The Cowra Meteorite: front view.

From a photograph taken from an accurate cast of the original by Mr. F. C. Wills.

Reduced—26 : 10.



Scale of centimetres.

Heliotype.

PLATE VIII.

Fig. 1.	Cowra iron:	etched figures, highly magnified.
Fig. 2.	Ditto:	natural size.
Fig. 3.	Bingera iron:	etched figures, natural size.
Fig. 4.	Ditto:	highly magnified.
Fig. 5.	Temora iron:	etched figures, highly magnified.
Fig. 6.	Ditto:	natural size.

Reproduced by the Photo-engraving Company, Sydney, from negatives prepared by Mr. F. C. Wills.

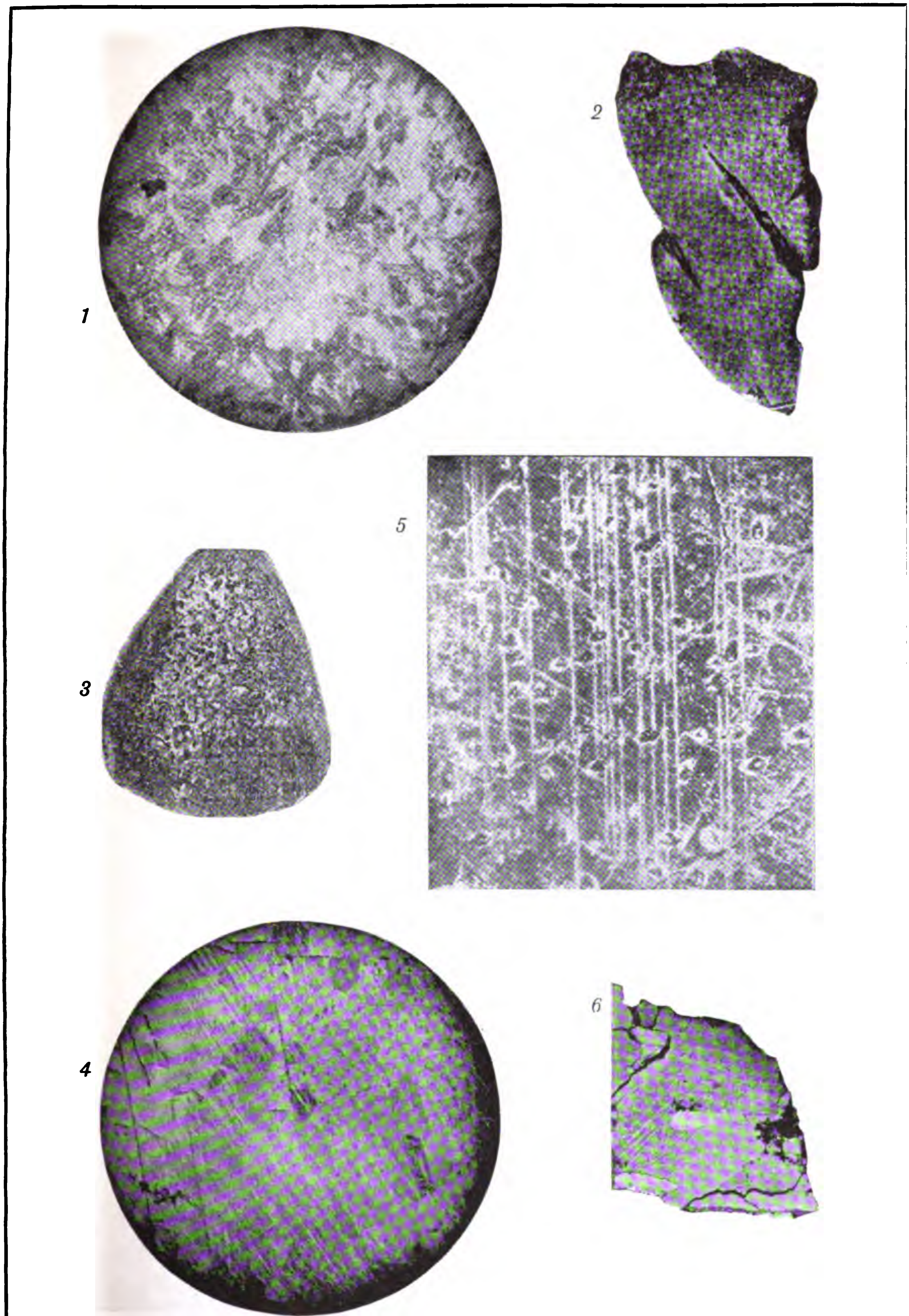

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PLATE IX.

Glossopteris rectinervis, *Dun.*

Fig. 1. Imperfect frond, from the Ward River.

Fig. 2. Portion of Fig. 1, enlarged to show the venation. x 2.

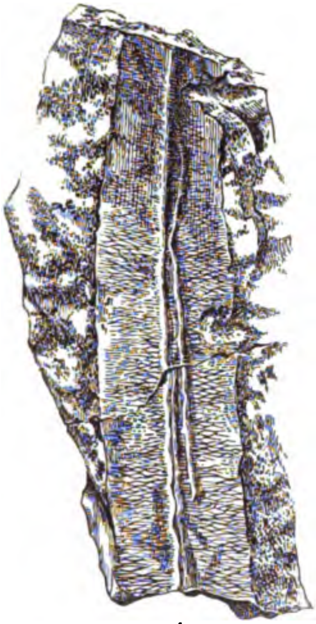
Fig. 3. Another leaf, showing a somewhat similar venation.

Glossopteris acuta, *Dun.*

Fig. 4. Portion of a frond, from Cremorne Bore, No. 1.

Fig. 5. Do do x 2.

Drawn from nature by Mr. F. R. Leggatt.



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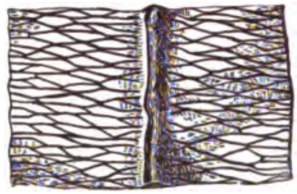

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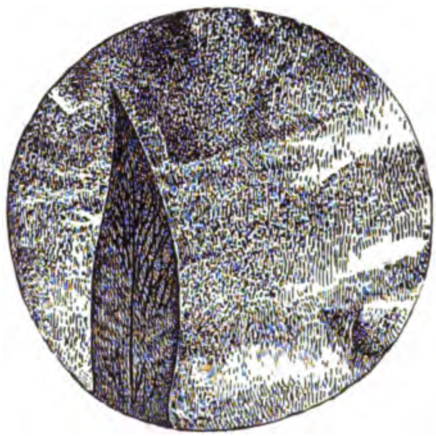

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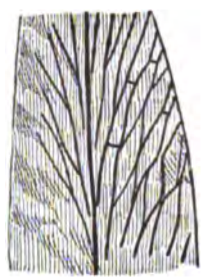

5

Frank R. Leggat, del.

Heliotype

DEPARTMENT OF MINES AND AGRICULTURE, SYDNEY.

RECORDS

OF THE

GEOLOGICAL SURVEY OF NEW SOUTH WALES.

Vol. V.] September, 1897. [Part 3.

XVII.—Geological Notes upon a Trip to Mount Kosciusko, New South Wales: by J. B. Jaquet, A.R.S.M., F.G.S., Geological Surveyor.*

The route taken was from Jinderbayne *via* Wilson's Valley, Piper's Creek Diggings, and Thompson's Flat to the summit of Mount Townsend. From thence a descent was made into the head of the Crackenback Valley, and Jinderbayne reached by way of the Thredbo Diggings. The country traversed has been geologically reported upon by two previous observers.†‡

The dominant country rock is granite, which, under dynamo-metamorphic influences, has been changed in places into gneiss. It seemed to me that the gneissoid character became more pronounced as the summit of the range was approached.

The foliation planes of the gneiss run approximately N.E. and S.W. and parallel with the main ridge.

Upon the eastern end of Boggy Plains, at the head of Wilson's Valley, I found dykes of a basic augite andesite intruding the granite. I had a microscopic section prepared from a specimen of this rock which I collected. It consisted essentially of porphyritic crystals of augite, olivine, and rarely felspar, imbedded in a micro crystalline base.

* The greater portion of this paper was embodied in my Report to the Government Geologist dated 9th June, 1895. [Ann. Rept. Dept. Mines and Agric. N. S. Wales for 1896 [1897], p. 133.] The Rev. J. Milne has also contributed some notes on the geology of this district to the Linnean Society of N. S. Wales. [Procs., 1897, XXI, Pt. 4, p. 819.]

† R. von Lendenfeld. Report on the results of his recent examination of the central part of the Australian Alps. (Folio, Sydney, 1885. By authority.) Petermann's Mittheilungen, 1887, Ergänzungsheft, Nr. 87.

‡ R. Helms, Procs. Linn. Soc. N. S. Wales, 1893, VIII, p. 349.

Near the summit of Kosciusko micaceous slates and schists are to be found. These rocks possess a perfect cleavage with planes which are approximately parallel with the foliation planes of the gneiss. They have been much crumpled and contorted, and in places have undergone a process of silicification. These characteristics can be particularly well observed in the gap between the highest peak upon the Kosciusko Plateau and the Ram's Head Range. Here they include lenticular quartz veins of a character similar to those which yield gold elsewhere in the Colony. I knocked off a piece of the quartz and had it assayed upon my return to Sydney, but it yielded neither gold nor silver. A gold reef is now being worked at Grey Mare's Bogong, about seventeen miles north of Kosciusko, in this same belt of rocks, and, in my opinion, the circumstances warrant a careful prospecting of the country between these two places being undertaken.

The question as to whether evidences of a former glaciation are to be seen upon the Snowy Mountains has long exercised the minds of geologists. Dr. R. von Lendenfeld, who examined the country in January, 1885, answers this query most emphatically in the affirmative.* He states that he found "rocks polished by glacial action in several places," and illustrated his report with a photograph of one of such rocks. Mr. Richard Helms, in a paper communicated by Prof. T. W. E. David to the Linnean Society of New South Wales, states that he searched carefully in the Wilkinson Valley and elsewhere for striæ and polished surfaces without finding them, though, he adds, the general appearance of the rocks at a distance suggested that they had been ground down by glaciers. Mr. Helms also records having found one piece of what he believes to be glacier-polished rock. In speaking of this specimen, he says, "there are, however, no striæ noticeable, which is rather remarkable, as they are generally present upon glacier-polished surfaces."

I did not see any polished surfaces or grooved rocks which might reasonably be supposed to have been produced by moving ice. Upon Thompson's Flat (Tom's Flat) I was able to identify, by means of the photograph which accompanies Dr. von Lendenfeld's report, the granite rock which he specially mentions as exhibiting glacier-polish. The smooth surface of this rock might well be the result of ordinary denudation. At the base of the mountains, and elsewhere in the Colony where granitic formations occur, similar smooth surfaces are to be found. The grooves are in section more or less V-shaped. They consist of ordinary planes of parting which have been enlarged by weathering along their lines of emergence. A penknife blade can in many instances be inserted into the cracks below the grooves.

I agree with Mr. Helms when he says that the rocks forming the range would disintegrate too rapidly to permit of glacier-striæ being retained upon their surfaces for any length of time.

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* *Op cit.*

Mr. Helms states that he found several terminal moraines, and he has also prepared a map showing the localities where he believes glacial deposits exist.

At Piper's Creek, which is situated at an altitude of five thousand six hundred feet, and is distant from Mount Kosciusko about eleven miles, gold has been found in shallow drift deposits consisting of black loam with subangular pebbles of granite and quartz. The gold occurs in patches and not defined "runs." During several months of the year the field cannot be approached with safety on account of the snow; and the rigorous climate and the long distance over which supplies have to be brought will always be against its advancement.

Thredbo Diggings are situated upon the Crackenback River, about twelve miles from Jinderbayne. The field at one time supported a large number of miners, but there are now only one or two "fossickers" upon it. The gold occurs in patches under a wide alluvial flat.

It was pointed out to me that a considerable amount of the gold occurred in the superficial and weathered portions of the granite, and I have had the same statement made to me in reference to auriferous drifts at Major's Creek, near Braidwood, which also rest upon granite. The waterworn character of the gold grains at both localities contradicts such a statement, and is undoubted evidence that the precious metal had been derived from elsewhere. Granite, owing to the facility with which its component felspars undergo kaolinisation, will, under favourable circumstances, rapidly disintegrate, and it would in many instances be impossible to distinguish between a bed of decomposed and collapsed granite boulders and a layer of the same rock which has weathered *in situ*. During my examination of the older gold-bearing gravels, etc., in the Shoalhaven Valley, I not infrequently found beds of disintegrated granite interstratified with beds of sand and gravel, and all the circumstances would seem to point to these beds having been formed as described above. To a miner this subject may be of great importance, since he might be liable in some instances to mistake a "false bottom" of decayed granite for the true bottom or bed-rock.

Since the date when this paper was written, the Author has again crossed the mountains in the vicinity of the Big Bogong Peak, about twenty miles north of Kosciusko, and found further intrusives of a basic character.

Between the head of Snowy Plain and the gap in the lower range which fronts the Big Brassy Mountain, dykes of a rather interesting dacite are to be seen intruding gneissoid granite. The rock has a specific gravity of 2·70. When freshly fractured it has a dark grey colour, and white quartz grains of considerable size, and small, glistening, black hornblende crystals can be distinguished by the naked eye. In thin sections under the microscope it is seen to consist of porphyritic crystals of hornblende and corroded quartz grains, imbedded in a micro-crystalline base composed of a more or less felted aggregation of hornblende

microlites and triclinic felspars. Some of the hornblende crystals exhibit a most beautiful zoning. (Slide 993, Geol. Sur. Coll.) An all-defined fluxion structure can sometimes be observed around the quartz grains. It may be that the intrusive rock has absorbed a portion of the granite, and that the quartz grains had their origin in this manner.

Upon the top of the range, about four miles south of the Big Bogong Peak, I found other intrusions of andesite. A microscopic examination of a section prepared from one of these rocks showed it to be very similar in character to the one last described. It, however, contains much less quartz. The porphyritic hornblendes are frequently twinned, some of them have been slightly crushed, and one crystal was found to be faulted. (Slide No. 994.) It would seem, therefore, that the andesites were intruded prior to the occurrence of the earth movements which produced the gneiss.

About half a mile south of the Grey Mare's Bogong Peak, and not far from the junction between the sedimentary rocks and granite a boss of amphibolite occurs. A microscopic examination showed it to consist of massive hornblende grains, with green and yellow coloured interstitial matter. Under the microscope the cementing material was seen to be composed of secondary quartz, which included partially decomposed fragments of hornblende and numerous minute and nearly colourless rods. The latter, one felt at first sight inclined to describe as acicular crystals of indeterminate or at any rate disputable character, similar to those which are so often found enclosed in quartz and other minerals. A closer investigation, however, shows them to consist for the most part of fine rods of hornblende which have become detached from the larger grains of this mineral. The rock was probably at one time composed solely of interlocking hornblende grains, and these have been replaced in part with quartz. The silica would seem to have crept into the rock between its component grains, and then afterwards to have grown forward, replacing the hornblende molecule by molecule. Minute plates or rods of hornblende resisted the attack of the acid solutions and, replacement proceeding beyond them, became detached and imbedded in the quartz. In many instances one can see such rods projecting, and in the act, as it were, of being floated off the original grains. (Slide No. 995.) A minority of the inclusions possess hexagonal and other definite crystalline forms, and could not have originated in the manner described above.

Near the entrance to the tunnel, which has been started upon the eastern slope of the Grey Mare's Bogong for the purpose of cutting the auriferous quartz-reef, doleritic dykes intrude the granite. When microscopically examined the dolerite is seen to be much crushed and otherwise altered. It consists essentially of augite and lath-shaped triclinic felspars with green alteration products. An ophitic structure can be observed in places.

In the Geological Survey Collection I found a diorite which had been collected from the top of the Big Bogong Peak. It is composed of brown hornblende, triclinic felspar, and hypersthene (?).

I also found a quartz-hypersthene-diorite from Kiandra, a small mining township, near the summit of the range, about twenty miles north of the Bogong. (Slide 807.) The minerals represented are quartz, felspar, and hypersthene. The latter exhibits straight extinction and the characteristic pleochroism; and the majority of the grains have partially undergone a paramorphic change, and are fringed with green hornblende. My colleague, Mr. G. W. Card, Curator and Mineralogist, has described a very interesting norite from Wyalong, which is largely composed of grains of hypersthene undergoing a similar transformation.

XVIII.—On the Occurrence of Devonian Plant-bearing beds on the Genoa River, County of Auckland: by W. S. DUN, Assistant Palæontologist.

[Plates X and XI.]

TOWARDS the end of last year Mr. J. E. Carne, Geological Surveyor, forwarded for determinations some imperfect specimens of ferns collected by him in the Parish of Genoa, County of Auckland. These specimens, unfortunately, are not only fragmentary, but show very little of the structure. Still, as our knowledge of the Devonian Flora of Australia is so small, it has been thought advisable that some notes on this occurrence should be prepared. Mr. Carne describes the general geology of this district in a preliminary report. He says—"From the coast to the Howe Range the formations consist of Devonian sandstones, conglomerates, and clay shales. At the Range about three hundred feet of conglomerates overlies the granite which forms the base of the elevated ridge stretching northerly from Mallacoota Lake to Twofold Bay. From the Howe Range to about one and a half miles west of the Eden-Genoa Road at Timbilica, the formations consist of slates, sandstones, and schists, with occasional intrusions of porphyry; from the intermediate position of these beds between the overlying Devonian and the more cleavable slates, and sandstones, and schists of the Monaro Tableland further west they may be provisionally classed as Upper Silurian, though continuous search has failed to discover palæontological evidence to definitely establish their proper geological horizon. West of the Timbilica Road granite occurs, being the southern extension of the Wyndham, Wolumla, and Bega outcrops. Stretching westerly into the Parish of Yambula it remains the surface rock. Frequent diorite

intrusions were noted but usually quite barren of quartz at the junctions. A narrow belt of Upper Silurian slates and sandstones stretches northerly from the Border across Mount Waalimma. West from this belt the granite is overlaid in the Yambula and Nungatta Ranges by massive beds of sandstone, conglomerates, and grey and ferruginous clay shales, reaching a thickness at some points of over 1,200 feet. These beds are practically horizontal or gently dipping. From the shale bands the party were successful in securing sufficient palæontological evidence . . . . to determine on reasonable grounds the true age of this series which I believe is identical with the beds of similar character in the Eden-Pambula District.*

From the Upper Devonian Beds of Iguana Creek, on the Mitchell River, in Gippsland, Sir Frederick M'Coy has described† *Archæopteris Howitti*, M'Coy, *Sphenopteris iguanensis*, M'Coy, and *Cordaites australis*, M'Coy, and, in my opinion, the first and last of these occur in the Genoa River Beds, which it is logical to assume to be of the same age. A very full account of these Iguana Creek beds will be found in Mr. A. W. Howitt's "Notes on the Devonian Rocks of North Gippsland."‡ Mr. R. A. F. Murray also deals with them at considerable length in his "Geology and Physical Geography of Victoria."§ At this place the plant beds consist of a band of grey-green shale in sandstone, and these beds with a very low angle of dip overlay almost vertical Middle Devonian at Tabberaberah. The series in the type district, Iguana Creek, is composed of conglomerates, sandstone, grits, shale, and thick reddish shales. It is probable that the Genoa River beds are synchronous with the Upper Devonian Beds of Iguana Creek, but this will be dealt with in detail by Mr. Carne in his final report.

II.—Descriptions.

Pecopteris, *Brongniart*, 1822.

(Mem. Mus. Hist. Nat., Paris, VIII, p. 33.

Pecopteris (?) obscura, sp. nov.

(Pl. X, figs. 1, 2; Pl. XI, figs., 6, 8.)

Under his name I venture to class the fern represented in Pl. x, figs. 1, 2, and Pl. xi, figs. 6, 8. It must clearly be understood that *Pecopteris* is used in a very wide and indefinite sense, as nothing is known of the venation or fructification. As will be seen by the figures, this fern was of a robust habit, with strong stem. Bipinnate and possibly tripinnate, pinnæ alternate, as a rule about one and a quarter inches long, and one inch apart. The pinnæ appear to be opposite, close, small, attached by the whole of their bases and not petiolate; entire, apex incurved and acutely pointed. The only trace of the venation that is preserved is the indistinct impression on several pinnules of a midrib extending to the apex; nothing is known of the secondary venation, assuming that there was one, so that

* Ann. Rept. Dept. Mines and Agric. N. S. Wales for 1896 [1897], p. 101.
† Prod. Pal. Vict., 1876, Dec. 6, pp. 21-23, t. 36.
‡ Geol Survey, Vict., Prog. Rept., III, 1876, pp. 181-249.
§ 8vo. Melbourne, 1887, pp. 60-65.

only a very unsatisfactory comparison of the genera can be made. According to Schimper's sub-division of fossil ferns into four larger families according to the venation:—Neuropterideæ, Adiantidæ, Sphenopterideæ, and Pecopterideæ, as summarised by Lesquereux,* the only one in which our Genoa fern can find a resting-place is the last. The Pecopterideæ comprise ferns with fronds simple, pinnate or bi-tri-pinnate, pinnæ alternate, pinnules adhering by base, sometimes confluent and lobed, entire or denticulate, primary and secondary venation, dichotomous. This large sub-division takes in ferns from the Devonian to the Cretaceous. Schimper, in Zittel's Palæophytologie, classifies sterile fronds under thirteen heads, Sphenopterideæ, Palæopterideæ, Neuropterideæ, Cardiopterideæ, Odontopterideæ, Alethopterideæ, Pecopterideæ, Pachypterideæ, Lomatopterideæ, Phlebopterideæ, Tæniopterideæ, Glossopterideæ, Dictyopterideæ, by means of venation and shape of pinnules. Of these, the only ones in which our fossil could fit, are the Odontopterideæ and Pecopterideæ, in the first-named the venation springing from the rachis and is furcate. On the whole there seems to be slightly more negative evidence in favour of its being classed as *Pecopteris.*

After searching through all the literature at my disposal I can find nothing to which this species can be compared, certainly it is not like any of the typical Pecopterids that have been figured.

Sphenopteris, *Brongniart*, 1822.

(Mem. Mus. Hist. Nat., Paris, VIII, 33.)

Sphenopteris Carnei, *sp. nov.*

(Pl. X, fig. 3; Pl. XI, figs. 3, 4, 5.)

The specimens figured prove the occurrence in these beds of an undoubted Sphenopterid fern of a Lower Carboniferous type. Some of the pinnules are entire, ovate, of the form of the recent *Adiantum*, resembling somewhat those of *Sphenopteris adiantoides*, Lindley.† In other cases the pinnules are incised, sometimes deeply, and approach in that respect to *Sphenopteris Hœninghausi*, Brongniart,‡ as figured by Andræ,§ and Potonié,|| but our fern differs much from this last in point of its greater size and different habit. The pinnules do not appear to be lobed but deeply incised, and in some cases this condition appears to be of a secondary nature, splitting. From the figures it will be seen that the pinnules vary very greatly in form, presenting an ovate entire outline, a more elongate shape, lobed and also of a deeply incised form. The very great range in pinnule form admissible in similar ferns will be seen in Potonié's paper on *Sphenopteris Hœninghausi* already quoted.

* 2nd Geol. Survey Penn., Description of Coal Flora, 1880, I. pp. 71-72.
† Foss. Flor. Gt. Britain, III, t. 115.
‡ Hist. Veg. Fossiles, p. 199 t. 52.
§ Vorweltliche Pflanzen, 1866, p. 13, t. 4, 5.
|| Jahrb. K. Preuss. Geol. Landesanstalt for 1890 [1892], XI, p. 16, t 7 and 8.

This form is bi-tri-pinnate, rachis slender, pinnæ opposite, pinnules petiolate, alternate, adiantiform, entire, or incised, venation simple furcate. In the literature at my disposal I can find records of no Sphenopterids closely approaching to this form and the comparison with *S. Hœninghausi* is mainly one of dissimilarity. There is no resemblance between it and any of the hitherto described Australian Sphenopterids.

Genus.—ARCHÆOPTERIS, *Dawson*, 1863.

(Canadian Naturalist, VIII, p. .)

(Fide S. A. Miller, Am. Pal. Foss., 1877, p. 22.)

(Pl. XI, Figs. 1–3.)

Archæopteris Howitti, M'Coy.

Archæopteris Howitti, M'Coy, Smyth's Progress Report Geol. Survey Vict., 1875, II, p. 73.

" " *Ibid.*, 1876, III, p. 62.

" " Couchman's Progress Report, Geol. Survey Vict., 1877, pp. 155–156.

" " Prod. Pal. Vict., 1876, Dec. 4, p. 21, t. 36, f. 1–2a.

" " R. Etheridge, junr., Catalogue of Australian Fossils, 1878, p. 209.

" " Feistmantel, Palæontographica, 1879, Suppl. Bd. III, Lief. 3, Heft 2, p. 142.

" " Feistmantel, Mem. Geol. Survey New South Wales, 1890, No. 3, p. 96.

" " Tenison Woods, 1883, VIII, Pt. 1, p. 96.

" " Feistmantel, Sitz. K. Bohm. Gesell. Wissen., Math.-Naturw. Cl., 1888, p. 627.

The portion of a pinna figured in Pl. XI, figs. 1–3, appears without doubt to belong to *Archæopteris Howitti*, M'Coy from the Devonian olive shales of Iguana Creek, Victoria. The agreement with M'Coy's figures is very close (with the exception that our specimen is smaller than the Victorian), and, also with the American species of the same genus, indeed it is hard to say whether this form should not be listed as one of them—the resemblance to the form described by Dawson as *Palæopteris Rogersi*,* being very noticeable. Sir Frederick M'Coy compares this specimen more particularly with *Archæopteris Jacksoni*, Dawson,† first described as a *Cyclopteris*, but from a comparison between his figures, Sir William Dawson's, and the specimen herein mentioned it appears to me that there is a closer approach of *A. Howitti*, M'Coy to *A. Rogersi*, than to *A. Jacksoni*, though the difference between all three is very slight, mainly that of size. From *A. hibernica*, Forbes, from the Devonian of Ireland there is a well marked difference in size, and relative position and form of the pinnules.

* Quart. Journ. Geol. Soc., 1863, XIX, p. 463, t. 17, f. 17, 18; t. 19, f. 27.
† *Ibid.*, XVIII, 1862, p. 319; XIX, 1863, p. 462, t. 19, f. 26.

Genus.—CORDAITES, *Unger*, 1850.
(Gen. et Spec. Plant., 2nd ed., p. 50.)
Cordaites australis, M'Coy.
(Pl. XI, Fig. 8.)

Cordaites australis, M'Coy, Smyth's Progress Rept. Geol. Survey Vict., 1875, II, p. 73.
" " Couchman's Ibid., 1877, IV, pp. 155, 156.
" " Prod. Pal. Vict., 1876, Dec. 4, p. 22, t. 36, f. 6, 7.
" " Etheridge, R., junr., Cat. Austr. Fossils, 1878, p. 80.
" " Feistmantel, Palæontographica, 1879, Suppl. Bd., III, Lief. 3, Heft 2, p. 142.
" " Feistmantel, Mem. Geol. Survey New South Wales, 1890, Pal. 3, p. 151.
" " Tenison Woods, Procs. Linn. Soc. New South Wales, 1883, VIII, Pt. 1, p. 155.
" " R. Etheridge, junr., Geol. and Pal. Queensland, 1892, p. 198.
" " Feistmantel, Sitz. K. Bohm. Gesell. Wissen., Math.-Naturw. Cl., 1888, p. 638.

To M'Coy's species *Cordaites australis*, the specimen figured in Pl. XI, Fig. 8, may be referred. Nothing more can be said of it than that it agrees with the original description, the clasping base is shown and the longitudinal markings are clearly shown, but the breadth is greater than in the original figures of *C. australis*. Sir Frederick says that it is common in the Devonian Beds of Iguana Creek, and the late Rev. Tenison Woods is of opinion that it occurred in Queensland, at Gympie and Drummond Ranges. Mr. R. Etheridge states in the above-mentioned work that he did not see specimens of it in the collections of Queensland fossils he worked over.

XIX.—Mineralogical and Petrological Notes, No. 6: by GEORGE W. CARD, A.R.S.M., F.G.S., Curator and Mineralogist.

1. The Mungindi Meteorite.
2. Cupro-scheelite from Yeoval.
3. Stolzite from Broken Hill.
4. Andesite from Myall, Tomingley.
5. Igneous Rocks met with at a depth in Artesian Bores.
6. Volcanic Glass from near Copeland.
7. Volcanic Ash from near Eden.

1. *The Mungindi Meteorite*:—This is an iron meteorite comprising two pieces weighing sixty-two and fifty-one pounds respectively. They are described as having been found, early in this year (1897), by a half-breed. They were lying

together, covered by the red soil, three miles north-north-east from the Mungindi Post Office, New South Wales, and therefore belong to Queensland territory. Several small pieces were detached, and two of these were sent to the Mines Department for identification. The meteorites were subsequently secured for the Mining and Geological Museum by Mr. E. C. Whittell, Field Assistant. The meteorite would appear to have lain for some time, as it is considerably weathered, so much so as to give rise in places to naturally-etched Widmanstätten Figures.

2. *Cupro-scheelite from Yeoval*:—This mineral has recently been detected at Taylor's copper mine, Upper Timby, close to Yeoval. The ore consists of bornite with copper carbonates, and the cupro-scheelite is closely associated with it. It is waxy in appearance and, while sometimes white, is generally of a greenish tint. In places rectangular outlines can be seen. Cupro-scheelite is known to occur at Peelwood, where it is intimately associated with scheelite and stolzite. An analysis of a sample picked from the material most nearly free from colour gave results as follows:—

Moisture and combined water	2·55
Tungstic trioxide	57·73 (66·7)
Lime	14·40
Magnesia	0·22
Ferric oxide	2·98
Alumina	trace
Copper oxide	7·08 (8·18)
Molybdic oxide	trace
Carbonic oxide	1·56
Gangue	13·04
	99·56

Neglecting the gangue, and recalculating the percentages of copper and tungstic trioxide become respectively 8·18 and 66·7. The percentage of tungstic trioxide is rather low, but there is not enough carbonic acid to account for the copper; moreover reactions for copper were invariably obtained with colourless fragments.

3. *Stolzite from Broken Hill*:—This mineral has been obtained in several different forms from the open cut at the Proprietary Mine.

(*a*) Flattened, leaden-gray, tetragonal pyramids with little or no prism.

(*b*) Leaden-gray tetragonal prisms with low pyramids.

(*c*) Claret-coloured pyramidal forms—perhaps hemihedral.

In all these the crystals are very small.

(*d*) Colourless or white crystals with adamantine lustre; very tabular in habit. These are of considerable size, the specimen in the Mining Museum having a length of side of more than a centimetre.

4. *Andesite from Myall, Tomingley*:—This is the country rock of the Myall reefs. The base is ferruginous and opaque, with numerous minute crystals of felspar scattered through it. In places devitrification patches of clear mosaic occur. Plagioclase, in phenocrysts, is seen in places altering into epidote, while more frequently the alteration is complete, the place of the felspar being taken by rounded patches of epidote and quartz. A distinct tendency to fissility is noticeable in the rock.

5. *Igneous Rocks met with at a depth in Artesian Bores*:—The following have recently come under notice:—

(*a*) Woolabra Bore, depth 1,779 feet. A fine-grained olivine-basalt. The olivine occurs as serpentine pseudomorphs, which are numerous. The base consists of very finely granular augite with minute lath-shaped felspars. Other felspars, of small size, are embedded in the base.

Woolabra Bore, depth 1,917 feet. Also basalt but not so fine-grained as the above. Augite is plentiful. Olivine comparatively fresh.

(*b*) Trangie Bore, depth 552 to 610 feet. A much-altered, dark greenish andesite. Opaque felspar, showing twin striation to the naked eye, is abundant. The felspar phenocrysts are much clouded by development of kaolin. Zoning by inclusion, and addition of felspar—material by secondary growth—are sometimes to be seen. Scattered through the base are numerous smaller lath-shaped felspars. Here and there are patches of undecomposed augite, (?) but the place of the ferro-magnesian silicate appears to be taken by isotropic green alteration products.

(*c*) Dargle Bore, depth 1,018 feet. A fine-grained rock, under the microscope seen to be much clouded by decomposition. Altered phenocrysts of felspar are embedded in a matrix consisting of numerous lath-shaped crystals, and aggregated groups of the same mineral, with numerous minute patches of quartz—apparently of secondary origin.

6. *Volcanic Glass from near Copeland*:—A beautifully perlitic glass of a brown colour, somewhat resembling common opal, and containing phenocrysts of very fresh orthoclase, showing perfect crystallographic outlines where not corroded by the matrix or penetrated by glass inclusions. Numerous simple crystallites are scattered through the base.

7. *Volcanic Ash from Eden.*

XX.—The Occurrence of Lower Silurian Graptolites in New South Wales: by W. S. DUN, Assistant Palæontologist.

IN November, 1896, Mr. J. E. Carne forwarded to the Department a collection of graptolite bearing shales from the Parish of Lawson, County of Wellesley. An examination of these specimens showed that they were undoubtedly Lower Silurian forms, and indicated beyond doubt the extension of the Victorian Lower Silurian Beds over the Border. This is a fact that has been reasonably expected for some time, and this, the first detailed examination of the districts along the Border, has added evidence of another formation occurring in New South Wales.

On the geological map of New South Wales this country is shown as of Upper Silurian Age, while immediately over the Border in Victoria Lower Silurian beds are mapped, and Mr. R. A. F. Murray mentions* "the discovery in the slates at Deddick, near the New South Wales boundary line, of a graptolite (*Diplograpsus rectangularis*, M'Coy), and the identification at Guttamurrh Creek, Snowy River, of *Didymograpsus caduceus* and *Diplograpsus foliaceus* in vertical slates capping the granite." The Rev. W. B. Clarke describes the general geology and features of these southern districts in various reports, but makes no allusion to Lower Silurian rocks;† while in the latest edition of his "Sedimentary Formations" he says, "of the graptolitidæ, only one is said to have been found in the Colony, and I presume that it is more likely to belong to the Upper Silurian than to the Lower, though towards the Victorian boundary, along the Deleget River, Lower Silurian rocks, according to some, are supposed to make their appearance."‡ Mr. C. S. Wilkinson, in his "Notes on the Geology of New South Wales," makes mention§ of altered sandstones and slates in the Murrumbidgee district, and near Moruya, "greatly resembling in lithological character the Lower Silurian bed of Victoria; but hitherto no fossils have been found in them." This statement is repeated in the second edition of this work.

In Victoria Lower Silurian rocks are largely developed, and in some localities—Bendigo, Lancefield, and Castlemaine—graptolites are abundant. These forms have been described by Sir Frederick M'Coy, and Messrs. Etheridge, T. S. Hall,

* Geol. and Phys. Geogr. Victoria, 1887, p. 42.

† On the auriferous character of the country along the Bendoc and Delegete Rivers (Report XIII). Papers relative to Geol. Surveys. New South Wales, 1852, No 7, pp. 22-25 (Fcap. Sydney, 1852. By Authority). Parl. Blue Book, Feby. 28, 1853, p. 72 (Fcap. London, 1853. By Authority). Southern Goldfields, p. 200 (8vo. Sydney, 1860).

‡ Sed. Form., 4th ed., 1878, p. 12.

§ Mineral Products of New South Wales, 1882, p. 39; 2nd edition, 1887, p. 53.

and Pritchard, and a list of the principal papers on the subject is appended. Sir Frederick classed these beds as Lower Silurian, and correlated them with the Welsh Llandeilo. Professors Marr* and Nicholson† speak of them as Arenig, *i.e.*, older than Llandeilo. They may also be correlated with the rocks of the Calciferous (Quebec) group of North America, many species of graptolites being common to the two formations. From the general resemblance of the New South Wales forms it is safe to approximately correlate the beds with the slates of North-eastern Victoria recently described by Mr. T. S. Hall.

Mr. A. R. C. Selwyn, late Director of the Geological Survey of Victoria, and then of Canada, says, speaking of Victorian Lower Palæozoic rocks, "east of the Snowy River, near Delegete, where the more slaty structure, characteristic of the lower beds, commences again, the double graptolites appear as the only fossil."‡

Mr. Carne briefly describes the geology of the Parish of Lawson in his Progress Report for the year 1896.§ He says:—"The Devonian Beds extend west along the Border to the junction of the Bondi River and Hopping Joe Creek, in the Parish of Bondi, County of Auckland. From thence to the main coast range in the same parish granite extends to near the brow of the tableland; here a narrow belt of slate and schist is separated from the main mass by a narrow intrusive offshoot of granite, which forms the eastern escarpment of the Manaro tableland on the Border. From this point to the Irondoon Range, just west of the Little River, slates, sandstones, and schists occur. At the Irondoon a narrow intrusion of gneissic granite occurs, but pinches out a short distance north of the Border. The sedimentary formations of the tableland fortunately afforded an interesting suite of graptolites."......This is the first definite determination of Lower Silurian rocks in the colony, which, however, was anticipated upon the occasion of the first geological examination of the district, opposite which in Victoria this formation had been identified." It appears, from the contained species of Graptolites, that these beds are higher in the series than those occurring at Castlemaine and Bendigo.

In a recent paper, Mr. A. E. Kitson remarks that owing "to the great inclination and lithological characteristics of the rocks" at Gehi Wall, Mt. Kosciusko, he considers them to be Ordovician. No fossils were found.‖

In February, 1897, Mr. Carne made further collections of graptolites from three other localities in the County of Wellesley:—(1) The south-west corner of Parish of Currowang; (2) Stockyard Creek, Parish of Alexander; and (3) from one and a half miles south of Portion 2, Parish of Tingaringi.

* Science Progress, 1896, V, p. 368.
† Manual of Pal., 1889, I, p. 222.
‡ Intercolonial Exhib. Essays, 1866–67 [1861], p. 12.
§ Ann. Rept. Dept. Mines and Agric., New South Wales, for 1896 [1897], p. 101.
‖ Proc. R. Soc. Vict., 1897, IX, (N.S.) p. 24.

The graptolites from the Parish of Lawson are imperfectly preserved as shiny films on a black slate, and in most cases little or nothing can be made out of their structure or specific relations. Generally speaking the species are small in size, and may be considered as dwarfed specimens of the characteristic Victorian species.

Dicranograptus furcatus, Hall.
" ?
Dicellograptus, sp. ind.
Didymograptus cf. caduceus, Salter. (?)
Diplograptus, cf. mucronatus, Hall.
" cf. rectangularis.
Phyllograptus. (?)

The form listed as *Dicranograptus furcatus*, Hall, is, I think, without doubt the same as that figured by McCoy* under the name of *Cladograpsus furcatus*, Hall sp. Dr. Gurley† states that Geinitz' genus *Cladograpsus* was not properly defined, and therefore should be dropped.

The forms referred to *Didymograptus caduceus*, Salter (?), are both small and of somewhat slender proportions.

The species of *Diplograptus* are the most common in this lot.

The *Phyllograptus*, perhaps a stunted form of *P. typus*, Hall, is uncommon.

The specimens from the south-west corner of the Parish of Currowang, County of Wellesley, are imperfectly preserved in a whitish, coarse-grained slate, stained with iron. They comprise—

Diplograptus cf. palmeus, Barrande.
Dicranograptus, sp.
Dicellograptus.

From Stockyard Creek, Parish of Alexander, County of Wellesley, preserved in a black granular slate. These forms are slightly better preserved—

Dicranograptus furcatus, Hall.
Diplograptus cf. palmeus, Barrande.
Diplograptus, sp., (? rectangularis, McCoy.)
Dicellograptus, sp.
" extensus, Hall.

From this locality some portions of the structure of *Diplograptus*, sp. Barrande, are exceedingly well developed and preserved; several specimens show the virgula, vadicle, and lateral spines very clearly and of considerable length. No signs of the projections of the hydrothecæ remain, and it is possible that this form may close to *D. rectangularis*, McCoy or even *Climacograptus*.

From a locality one and a half miles south of Portion 2, Parish of Tingaringi, County of Wellesley we have—

Diplograptus, cf. palmeus, Barrande.
Didymograptus, sp.
Dicranograptus furcatus, Hall.
Dicellograptus, sp.

* Pal. Prod. Vic., Dec. II, p. 34, t. 20, f. 7.
† Journ. Geology, 1896, IV, Pt. 1, p. 93.

From a comparison of these lists, it will be seen that *Dicellograptus*, *Diplograptus* and *Dicranograptus* are the commonest genera. A doubtful *Phyllograptus* occurs at Parish Lawson only. It is unfortunate that the state of preservation of these delicate organisms is so unsatisfactory, and it is possible that further collections may throw more light on the species preserved. Still it seems to be beyond all doubt that these beds denote an extension into New South Wales of the Victorian Lower Silurian Series, and we may hope soon to find the relation between the slates and the Upper Silurian beds so well developed a little to the north of this.

A list of papers on the Victorian Graptolites is appended for the information of readers:—

List of Papers relating to Australian Graptolites.

ETHERIDGE (R., Junr.) :—

Observations on a few Graptolites from the Lower Silurian Rocks of Victoria. *Ann. Mag. Nat. Hist.*, 1874, XIV (4), pp. 1–10, t. 3.

A Catalogue of Australian Fossils. Pp. 4–10. (8vo., Cambridge, 1878.)

HALL (T. S.) :—

On a New Species of Dictyonema. *Procs. R. Soc. Vict.*, 1892, IV (n.s.), pp. 7–8, t. 1, 2.

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XXI.—The Diatomaceous Earth Deposits of New South Wales: by G. W. CARD, A.R.S.M., F.G.S., Curator and Mineralogist; and W. S. DUN, Assistant Palæontologist.

[Plates XII–XV.]

I.—General Character of Diatomaceous Earth.

THE Diatomaceæ or Bacillariæ are microscopical confervoid Algæ, living in both salt and fresh water. The plants consist of either a single diatom or frustule (*Navicula, &c.*), or else of an aggregate of the frustules forming filamentous strings (*Melosisa, Diatoma*). This frustule consists of a cell enclosed in a siliceous carapace consisting mainly of the two valves and the zone, cingulum, or girdle consisting of the overlapping portion of the valves. In the scope of this paper we are concerned only with the general form presented by the siliceous hollow structure formed by the valves. It is formed of colloidal silica secreted by the organism, and the shape is extremely variable, the ornamentation being arranged longitudinally, radially, transversely, in lines, dots, or pits, and may be alveolate (coarse dots), striate (fine lines formed by minute punctures), costate, or moniliform. All diatoms possess a raphe or median cleft or line with central and terminal nodules, according to Van Heurck, though in some cases these are very obscure. On this character the main subdivision of the Diatomaceæ into Raphidiæ, Pseudoraphideæ, and Cryptoraphideæ is based.

As before remarked, diatoms inhabit fresh and salt water, and some forms even live in damp soil. Their distribution is exceedingly wide, from the Tropics to the Arctic and Antarctic Regions, and on lofty ranges of mountains. The marine forms differ generically as a rule and invariably specifically from the fresh water, but there is a certain mingling, as might be expected, in brackish water, which also has its characteristic species. The geological range is also great, from the Carboniferous to the present time, though deposits are not of frequent occurrence till the Tertiary is reached. According to Dr. Van Heurck* the oldest deposit occurs in the London Clay (Lower Eocene), and is described by Mr. W. H. Shrubsole.† Numerous forms were found here, and were pyritised and encrusted with pyrites. Schimper mentions Diatoms in Upper Cretaceous Beds,‡ while§ in a footnote he draws attention to Castracane's discovery of existing species in the English Coal Measures. I have been unable to refer to the original paper,|| but in his paper

* Treatise on the Diatomaceæ, p. 43. (4to. London, 1896.)
† Journ. R. Micros. Soc., 1881, , p. 381.
‡ Tillet's Handb. de Pal., Abtheil. II, p. 14.
§ *Loc. cit.*, p. 14.
|| Jahrb. Wiss. Bot., 1874, x; Atti Accad. Pontif. Nuovo Lincei, xxvii, 1874.

in the Comptes rendus* he states that Diatoms have been found in the Carboniferous at Liverpool, Newcastle, St. Etienne, and in the Scotch Cannel. Schimper quotes the following species as being found by Count Castracane—*Fragilaria Harrisoni* (Sm.), *Epithemia Gibba* (Ehr.), *Sphenella glacialis* (Ktz.,) *Gomphonema capitatum* (Ehr.), *Nitzschia curvula* (Ktz.), *Synedra vitrea* (Ktz.), *Diatoma onlgare* (Bory.) This list serves to show what little variation there has been in these minute organisms during the course of time.

The abundance of these organisms under favourable conditions may be gathered from the fact that "A deposit of mud no less than four hundred miles long by one hundred and twenty miles broad was found at a depth of between two hundred and four hundred feet, on the flanks of Victoria Land in 70° south lat."† This deposit is composed of Diatom ooze, its thickness is unknown. In the Antarctic Regions the sea is often thick with Diatomaceæ, which also tinge it and the ice a dull yellow. Instances are also on record of shallow estuarine harbours being choked by their rapid accumulation. Ehrenberg has estimated that one cubic inch of Diatomaceous Earth, contains about forty-one billion frustules.

II.—Physical Properties.

The existence of deposits of Diatomaceous earth in New South Wales has long been known and, from time to time, the possibility of utilising these, more especially in the manufacture of dynamite, has been considered. Many new uses are now being found for the material, and the subject has locally aroused considerable interest, suggesting the advisability of bringing together the information now available.

Diatomaceous earth is a siliceous material, generally more or less white in colour and frequently pulverulent in nature, found in very many places widely distributed over the globe. It is known under a variety of names, more or less appropriate. Of these "infusorial earth" was at one time very generally used, but its inaccuracy has led to its becoming less common: it is still frequently met with however. The objection to its use is that true Infusoria do not enter into its composition at all. The German name, "kieselguhr," having reference to its siliceous nature is generally used commercially. Another equally common term is "tripolite" derived from Tripoli, in North Africa, where extensive deposits occur. It is advisable perhaps to avoid confusion by dropping this term to a certain extent, as it is applied in America to various siliceous earths differing entirely in constitution from true infusorial earth, more particularly to a material now mined in large quantities in Missouri, and referred to more particularly below. A pure diatomaceous earth would consist of silica and water only. The silica is in the colloidal condition, and

* Comptes rendus Acad. Sci. Paris, 1874, lxxix, p. 52.
† Myers, Introd. Study Diatomes, p. 2. (8vo. London, 1893.)

the water exists partly combined and partly as absorbed moisture. For purposes of comparison it is perhaps advisable to calculate percentages after neglecting the moisture which is a variable quantity depending upon external circumstances such as time of exposure. This ideal composition is seldom met with, varying proportions of carbonates of lime and magnesia, clay, &c., being generally present. The percentage of silica is generally between eighty and ninety. Occasionally organic matter is present in sufficient quantity to colour the earth, and also to maintain combustion for calcination purposes after having once been ignited. This is the case with some of the German earths. The presence of iron is frequently revealed by the red or yellow colour of the calcined material. In some cases too, as will be again pointed out, the percentage of silica is increased by its extraneous introduction. Consisting as it does of silica, diatomaceous earth is not affected either by extreme heat or by acids, but being in the colloidal form is readily acted upon by alkaline solutions. The characteristic physical property of tripolite is its extreme lightness, the specific gravity being less than one quarter that of water. With low density is correlated excessive porosity, both being determined by the structure of the individual organisms composing it. As these organisms will be fully described below, it will now suffice to remark that, consisting as they do of very delicate siliceous membranes enclosing a space, it follows that the earth comprises a vast number of air cavities capable of being occupied by any liquid absorbed. In this way an average sample of diatomaceous earth will absorb from four to five times its own mass of liquid. When saturated the density increases to about 1·24, and the rock will sink in water. It is to these three properties of low density, porosity, and resistance to heat and acids that tripolite owes what value it may possess. The earth was known to the Greeks and Romans, Strabo writing about building stones of such lightness that they float upon water, and the Emperor Justinian instructed his architects to use it in building the dome of Hagia Sophia. After calcination the specific gravity is increased by about fifty per cent.

ANALYSES of Diatomaceous Earths from Foreign Localities.

	Germany.	Germany.	Hanover.	Hanover.	Hanover.	Hanover.	Hanover (Hermannsberg).	Bilin.	Bilin.	Laugschiefer.	Oberohe.	Scotland.
Silica	8·01	92·08	86·4	91·3	80·9	79·8	84·15	87·53	74·20	80·30	96·85	92·0
	82·97	**98·90**	**95·01**	**97·33**	**93·14**	**95·23**	**94·44**	**95·12**	**91·24**	**92·75**	**100·00**	**97·35**
Ferric oxide	6·82	0·23	1·5	1·0	1·8	2·6	0·70				trace	
								2·04	6·81	5·40		2·50
Alumina	7·13	0·79	1·6 (clay)	1·0 (clay)	3·5 (clay)	1·9 (clay)	1·40				trace	
Lime	....	....	1·3	0·2	1·6	0·3	1·75	1·09	0·41	0·44	....	....
Magnesia	....	....	....	0·3	....	0·4	1·10 (carbonate)	0·30	....	0·43	....	....
Water	8·45	5·21	6·9		8·3		10·40	8·89	13·30	10·90	3·15	
				6·2		15·0						5·50
Other volatile matter	8·17	1·04	2·3		3·9		....	....	4·20	1·30	....	
	98·58	99·35	100·00	100·00	100·00	100·00	99·50	99·90	98·92	98·77	100·00	100·00

	Scotland (Aberdeen).	Tuscany (Santa Flora).	Auvergne (Ceyssat).	Nevada (Little Trucker River).	Nevada (Storey County).	Maryland (Pope's Creek).	New Jersey (Morris County).	Virginia (Richmond).	Mauritius.	Australasia (loc. ?)	Canada (New Brunswick, Pollett Lake).
Silica	95·34	79·0	87·2	91·43	81·08	81·53	80·66	75·86	72·0	87·40	*80·437
	96·31	**83·78**	**97·71**	**95·57**	**100·00**	**84·45**	**94·80**	**83·74**	**92·20**	**99·26**	**94·45**
Ferric oxide		3·0	....			3·33	....	2·92	2·5	0·65	0·051
	3·65			3·62	....						
Alumina		5·0	2·0			3·43	3·84	9·88	2·5	....	3·146
Lime	....	....	....	0·25	....	2·61	0·58	0·29	....	....	0·342
Magnesia	....	....	....	0·36	....	5·63 (with K_2O, Na_2O, &c.)	....	1·63 (with K_2O, Na_2O, &c.	....	....	0·283
Water	0·03	12·0	10·0	3·30		3·47		8·37	21·0	8·22	
					18·44		14·01				13·332
Other volatile matter	0·32	....	....	....		....		....	....	2·15	
	99·34	99·00	99·20	99·46	99·52	100·00	99·09	98·95	98·00	93·42	98·54

* 92 per cent. of the air-dried material was soluble in caustic potash.

The silica percentages printed in black type have been calculated after neglecting all water and volatile matter.

ANALYSES of Diatomaceous Earths from New South Wales.

<table>
<tr><th></th><th>Barraba, 3 miles from.</th><th>Barraba.</th><th>Barraba.</th><th>Glen Innes, 32 miles from.</th><th>Richmond River, Wyrallah.</th><th>Richmond River, Wyrallah.</th><th>Cooma.</th><th>Cooma.</th><th>Cooma.</th><th>Warrumbungle Mountains.</th><th>Warrumbungle Mountains.</th><th>Queensland, Pine Creek.</th></tr>
<tr><td>Silica</td><td>71·62
80·66</td><td>71·13
81·54</td><td>80·56
......</td><td>71·53
81·85</td><td>86·01
96·81</td><td>90·94
96·25</td><td>81·64
91·83</td><td>83·30
94·28</td><td>80·94
90·79</td><td>82·62
93·07</td><td>72·94
81·68</td><td>89·10
99·34</td></tr>
<tr><td>Ferric oxide</td><td rowspan="2">14·07</td><td>0·91</td><td>1·77</td><td>trace</td><td rowspan="2">2·83</td><td>0·49
ferrous oxide.
0·33</td><td>0·40</td><td>0·36</td><td>1·23</td><td rowspan="2">5·20</td><td>0·87</td><td rowspan="2">0·59</td></tr>
<tr><td>Alumina</td><td>13·06</td><td>4·15</td><td>14·36</td><td>2·38</td><td>3·20</td><td>3·84</td><td>4·61</td><td>4·57</td></tr>
<tr><td>Calcium carbonate</td><td>1·43</td><td>0·31
(lime)</td><td>0·31</td><td>0·82</td><td>trace</td><td>......</td><td>1·50</td><td>0·30
(lime)</td><td>0·86</td><td>0·95</td><td>9·53</td><td>trace</td></tr>
<tr><td>Magnesia carbonate</td><td>1·66</td><td>0·87
(magnesia)</td><td>0·21</td><td>0·68</td><td>trace</td><td>trace</td><td>2·16</td><td>0·36
(magnesia)</td><td>0·45</td><td>trace</td><td>0·70
(magnesia)
0·69</td><td>......</td></tr>
<tr><td>Sodium chloride</td><td>......</td><td>Carbon dioxide.
0·95</td><td>......</td><td>......</td><td>......</td><td>0·32</td><td>......</td><td>0·25</td><td>1·06</td><td>........</td><td>... .....</td><td>......</td></tr>
<tr><td>Combined water</td><td>4·03</td><td>5·67</td><td rowspan="2">12·84</td><td>6·14</td><td>5·96</td><td>2·79</td><td>3·77</td><td>5·84</td><td>2·99</td><td>3·49</td><td>3·08</td><td rowspan="2">10·31
(with organic matter.)</td></tr>
<tr><td>Moisture at 100° C.</td><td>7·30
(with organic matter.)</td><td>7·33</td><td>6·50</td><td>5·36</td><td>2·69</td><td>7·18</td><td>5·40</td><td>8·07</td><td>7·70
(at 105° C.)</td><td>7·88</td></tr>
<tr><td></td><td>100·11</td><td>100·23</td><td>......</td><td>100·03</td><td>100·16</td><td>99·94</td><td>99·85</td><td>99·65</td><td>100·21</td><td>99·96</td><td>100·26</td><td>100·00</td></tr>
</table>

The silica percentages printed in black type have been calculated after neglecting all water and volatile matter.

Notes on the Analyses.—Comparing the silica proportions it will be noticed that the highest in New South Wales is that given by the Wyrallah earth. It must be remembered, however, that a portion of this silica appears to have been deposited from solution, binding the whole into a compact mass and not in any way adding to its absorbent properties. The extreme purity of some of the foreign earths, more particularly those from Oberohe and Storey County, Nevada, will be noticed. Magnesia and lime vary much in quantity, reaching ten per cent. in one of the Warrumbungle samples. Whereas some of the German earths contain a very high percentage of organic matter, sufficient, in fact, to effect their calcination, New South Wales earths contain but little volatile matter other than water. The analyses have been conducted upon samples in very varying conditions of dryness; to permit of ready comparison on a uniform basis the silica percentage has been recalculated in each case after neglecting all volatile matter. In the case of such wet earths as that from Mauritius and one of the Bilin samples the silica content is thus made much more prominent.

IV.—Economic Characters, &c.

Uses and Properties.—The combination of valuable physical properties possessed by diatomaceous earth has led to its utilization in a variety of ways. Its application in the Arts will be dealt with under the heading of the property to which its value is due.

Abrasion.—This is due to the hardness, sharpness, and minute size of the individual particles of which diatomaceous earth consists. When levigated it constitutes an admirable polishing powder. In the case of very finely pulverulent earths like the Victorian little or no preparation is needed: indeed, polishing powders consisting of the earth either crude or but slightly prepared have been placed on the market in Australia and Canada under various brands. By mixing the pulverised material with the usual ingredients a valuable soap has been manufactured.

Absorbency.—This property is due to the structure of the individual micro-organisms. Consisting as they do of an external skeleton partially enclosing a space, it follows that a piece of Diatomaceous earth contains an innumerable number of cavities (as before-mentioned a cubic inch contains some forty-one billion diatoms). On immersion in liquid the air is displaced from these cavities and the liquid absorbed. In this way diatomaceous earth can absorb, on an average, from four to five times its own mass of water. This property has been taken advantage of in a number of ways, more particularly in the manufacture of explosives. It was formerly largely used in the manufacture of dynamite, where it served as an absorbent for the nitro-glycerine. It is now, however, being replaced by wood-pulp and other cheaper substances. The German earth is said to be better fitted for this purpose than the American. We hear that in a recent Report of the United States War Department the Victorian tripolite was said to

be the very best in the market for this purpose. In a variety of minor ways this property has been made use of, such as for carrying disinfectants in hospitals. The firm of G. W. Reye and Sons, Frankenstrasse 28, Hamburg, has introduced a series of useful articles.

Solubility.—Although quite unaffected by acids, the silica of diatomaceous earth, being in the colloidal condition, is readily dissolved by alkaline solutions with the formation of a silicate of the alkali. In the case of the Pollett Lake Earth Hoffman found that 92 per cent. of the air dried material was soluble in boiling caustic potash. In the form of soluble silicate of soda or water-glass it has been used as a cement for building stones, &c. In general, however, clean white sand would probably be found cheaper.

Low Specific Gravity.—Very early attention was drawn to tripolite by its low density. A cubic yard of tripolite fire-bricks was found to weigh twelve hundred-weights, only one-fourth the weight of the same volume of Dinas bricks. The Emperor Justinian (522 A.D.) directed his architects to make use of such bricks in building the dome of the Hagia Sophia at Constantinople. In rough country the advantage of bricks of such lightness, where carriage is difficult and costly, is evident.

Non-Conductivity to Heat.—It is to its ultimate composition again that diatomaceous earth owes its remarkable properties as a non-conductor of heat. In passing from one medium to another heat suffers a certain amount of loss by reflection and refraction. In consequence of the innumerable air cavities the heat waves have to pass repeatedly from silica to air, from air to silica, and suffer a corresponding loss in energy; their intensity is thus very quickly reduced in traversing a small thickness of tripolite. A brick may be held in the hand at one end while the other is being strongly heated. It is to this property that it owes somewhat extensive use for boiler and steam-pipe covering. In this sphere of usefulness the competition of asbestos packing has to be met; scrap mica is also being now used for this purpose. It is, or has been, used by the P. and O., Orient, Inman, and White Star Lines. The American earths have been found more suited for this than they are for the manufacture of explosives. It has been suggested that tripolite would be found equally resistant to electricity, and could thus be used for the insulation of telegraph and other wires.

Infusibility.—Consisting as it does of practically pure silica, tripolite is an admirable refractory material; at ordinary temperatures it is indeed quite infusible. From time to time attempts have been made to use it in the manufacture of fire-bricks, with what success it is rather difficult to ascertain. In the "Mineral Resources of the United States"* reference is made to "Kieselguhr fire-brick" manufactured by a North London Company. Their lightness is said to render them specially suited for blast furnace pipes, covering retorts, for special purposes in

* Mineral Resources of the United States, 1893, p. 607.

chemical works where non-conducting properties are desirable, and for retort settings in gas-works. The specific gravity of a manufactured brick is given as 0·6. Their success is said to be undoubtedly established. Some inquiries made in London by the Authors with a view to obtaining the address of this Company were not successful. The average analysis of the earth from which these bricks were made is given as follows:—

Silica	83·8
Magnesia	0·7
Lime	0·8
Alumina	1·0
Ferric oxide	2·1
Organic matter	4·5
Moisture and loss	7.1
	100·00

Some experiments made by Hoffman with the earth from Pollett River Lake, New Brunswick, are of interest.* Five test bricks were made having the following proportions:—

1.	Diatomaceous earth alone.			
2.	Do	95 parts,	white pipe-clay	5 parts.
3.	Do	90 do	do	10 do
4.	Do	99 do	lime	1 do
5.	Do	98 do	do	2 do

The earth and clay were air-dried, and the lime freshly prepared. The bricks were moulded in a small hand-press, air-dried, and finally dried at 100° C. They were then placed in covered crucibles and heated in an air furnace, the temperature being gradually raised for an hour, and then maintained at a white heat for two hours. All five were found to have perfectly retained their form, and their edges were perfectly sharp. All were highly absorbent, firm, and tough. Nos. 1, 2, and 3 had very smooth surfaces and a fine close texture; they decrepitated strongly when suddenly plunged into the flame of a blast lamp. Nos. 4 and 5 were looser in texture and stood well. All were excellent non-conductors. The contraction was greatest in Nos. 2 and 3—11·18 %, and least in 5—7·89 %. Nos. 4 and 5 were quite white, while 1, 2, and 3 were uniformly creamy in colour. Hoffman notes that this is in accordance with the fact that the alkaline earths, especially lime and magnesia; have a singular power of bleaching ferruginous clays in the kiln, so low a proportion as 5 % of caustic magnesia mixed with a red clay entirely destroys its red colour. In weight No. 3 was heaviest, and 4 lightest. Several attempts have been made in New South Wales to manufacture Kieselguhr fire-bricks. At the Bulli Tile Works bricks were made with a mixture of tripolite and the local fire-clays. After having been built into the furnaces for about three months, however, the bricks were found to shrink to an enormous extent, and their manufacture has been given up.

* Prog. Rept. Geol. Survey, Canada. Montreal, 1879-80, p. 3 H.

Miscellaneous Uses.—Attempts have been made to utilise tripolite in packing fruit for export, with what results the Authors are unaware. Locally it has been used in the manufacture of refrigerating paint, but as no attempt has been made to place it on the market no comparison can be made with other similar preparations. It is found of service in packing acids for transport. The United Kieselguhr Company at Chelle also utilise the German earth for ice manufactories, rendering floors, walls, and ceilings fire and rot proof, as a filling for ice-chests, fire-proof safes, strong-rooms, &c. It is sold either pure or as composition (mixed with asbestos or hair).

Value and Production.—Very little has as yet been done with the New South Wales deposits. At Cooma a small quantity has been raised for experimental purposes, and 676 bushels of Richmond River tripolite were shipped from Grafton for trial during 1896. In the latter case a price of 3s. 6d. per bushel was obtained, but out of this all expenses had to be met. The Victorian (Lilicur Creek) earth is of such a remarkably fine quality that it is able to command a high price; accurate statistics are not available. In America the price appears to vary from about twenty to fifty shillings per ton of two thousand pounds. The production in the United States in 1894 was 2,584 short tons. At the Bass River, Nova Scotia, some 400 tons, said to be worth about £4 a ton, were raised during 1895. In Nevada mining is not prosecuted regularly, enough being obtained in one year to meet the demand for some time. It is difficult, however, to get accurate statistics, as tripolite is generally included with other substances in returns.

In conclusion, it would appear as if the deposits of diatomaceous earth in New South Wales cannot compare in quantity with those of America and elsewhere. In quality there is perhaps little to choose, but they cannot compare with the very fine Victorian earth. The Barraba, Warrumbungle Mountains, and perhaps some others, are too far from rail for profitable working. Cooma and Wyrallah are conveniently situated in this respect, the former being near the railway, the latter being accessible to water carriage. There is as yet no great demand for Diatomaceous earth, and should the demand arise, the quantity available in almost every part of the world is practically inexhaustible.

V.—Foreign Occurrences.

The records of foreign occurrences of Diatomaceous earths are so numerous that only a few of the more importent or more interesting are mentioned in this paper.

A laminated fissile variety known as "polirschifer" occurs in numerous European and South American localities, notably near Bilin, Bohemia. Here it is described as occurring above gneiss and a gypseous clay and protected by a capping of phonolite. At Lausitz it occurs above and below brown coal, and is covered by basaltic tuffs and lavas. Between Kasan and Saratov on the Volga the beds of polishing slate are said to attain a thickness of forty feet.

Leaf and fish remains, or even beetles, are sometimes found in the earth, and its geological age when known is generally Tertiary or Post-tertiary. Tripolite proper only differs from polirschiefer in not possessing a fissile structure. It is generally of Tertiary age* and frequently occurs in peaty districts. There are very many deposits in Europe of which several are worked. That at Naterleuss in Hanover yields kieselguhr of the purest quality and lowest specific gravity. It there attains a thickness of 150 feet, and is covered by thin alluvial beds. The upper portion is white in colour and contains some sand. After washing it affords an excellent material. At a lower level there is less sand, but the presence of organic matter affects the colour. There is sufficient organic matter to effect calcination, and kieselguhr of the finest quality results. The lowest stratum is rendered green in colour by the presence of as much as 30 per cent. of organic matter. It is calcined in kilns, yielding a red kieselguhr, the colour being due to ferric oxide. The Hanover deposits are characterised by the presence of the forms *Synhedra ulna* and *Gaillonella* (*Melosira*) *aurichalcea*. On the north side of the Hochsimmer near Eltringen diatomaceous earth is associated with pumice and tuffs, the latter also containing diatoms.

At Franzenbad in Bohemia a deposit from six to eight feet thick occurs in a marshy district; the principal forms are *Navicula*, *Gomphomena*, and *Melosira*. At Altenschlirf and Steinfurth in the Vogelsberg the prominent forms are the fresh-water sponge *Spongilla* and *Melosira distans*; the thickness is from eighteen to twenty-four feet. Near Bauzten the earth has a yellowish colour and is granular in nature; *Fragillaria construens* is abundant. Berlin is partially built on a deposit of Diatomaceous earth. German kieselguhr has very high absorbent properties; the American is less absorbent. Very many deposits are known in America, some of extraordinary thickness, and a few of them have been worked. It has been noticed that the American beds are commonly found in swamps representing filled-up lakes of the glacial period. The most important producing district is Pope's Creek, Maryland. A large deposit has been recently discovered in Florida. At Richmond, Virginia, there is a well-known bed of diatomaceous earth extending across the State from north to south for more than a hundred miles. It is about thirty feet thick. The earth is yellow and clayey in appearance and is of Eocene age. At Monterey, California, it attains a thickness of fifty feet, and is also Tertiary. On an arm of the Upper Columbia River, Fremont discovered a deposit of porcellanous diatomaceous earth under a covering of basalt. It contained plant remains, and was no less than 500 feet thick. At Fossil Hill, Nevada, a thickness of 200 feet is attained. Numerous lake deposits of diatomaceous earth occur in various parts of Canada, more especially in Nova Scotia and New Brunswick. They are very numerous in the marshy districts of Nova Scotia.

* The fact that Diatomaceous deposits are rarely older than the Tertiary epoch would not appear to have much significance. The ready destructibility of such incoherent rocks and their solubility in alkaline solutions facilitates their obliteration. If preserved at all in the older formations they should perhaps be looked for in compact chert beds comparable to the now well-known radiolarian cherts.

One of the largest occupies the bed and shores of Folly Lake, on the Intercolonial Railway. It is believed that these lakes could be readily drained. The material is being mined at Bass River, near Truro. Of the New Brunswick deposits, that at Pollett River Lake is perhaps the best known. Some important experiments conducted on the Pollett River earth have been referred to. In Chili a deposit composed of forms found living in neighbouring thermal springs occurs associated with pumice.

Recently the existence of diatomaceous earth has been noted at Lake Rudolf, East Africa.

A material occurring near Pontgibaud, and known as Randannite, must also be regarded as a diatomaceous earth.

Various siliceous substances have been incorrectly classed with infusorial earth, and a brief reference to some of these will be advisable. First among these is the Tripoli, extensively mined at Seneca, in south-west Missouri. This contains 98 per cent. of silica, and is believed to be either a siliceous limestone, from which the calcareous matter has been leached out, leaving a spongy mass, or a decomposition product from a clay.* It is very extensively used for filters, blotting pads, and as powder for polishing purposes. In Socorro County, New Mexico, there is a deposit also called Tripoli, containing about 80 per cent. of silica, occupying a depression in a volcanic country. It appears to have been formed of the débris of siliceous volcanic scoriæ.† It is not equal to tripolite as an abrasive. At Santa Fiora, in Tuscany, there is a white polishing slate consisting of irregularly formed little grains and chips of opal.‡ Another so-called kieselguhr comes from Foissy, in Belgium. It is composed of globular little opal bodies which absorb pigments with great avidity.

In New Zealand deposits of diatomaceous earth are numerous, both of fresh-water and marine origin, the latter being the more important. These are classed as Pliocene mostly, though some are of more recent formation. The best known is that at Oamaru, which has yielded to the studies of Messrs. Grove & Sturt,§ and Messrs. Hinde & Holmes,‖ a large number of species of Diatomaceæ and sponge spicules, and extends the range of several species occurring in the Barbadoes Deposits. This siliceous deposit also contains Radiolaria, and is considered to be of Eocene age. A general account of the geology of this deposit will be found in a paper by Mr. H. A. de Lautour.¶

* Amer. Geologist, 1896, XVIII, No. 3, p. 136.

† *loc. cit.*, pp. 136–140.

‡ There is, however, a true kieselguhr deposit an Santa Fiora.

§ Journ. Quekett Micros. Soc., Ler. 2, II, III, 1886, 1887.

‖ Journ. Linn. Soc., 1892, XXIV, p. 177.

¶ Trans. N.Z. Inst., 1888, XXI, pp. 293–311, pls, 18–23. Other papers on this subject are :—McKay (A.) On deposit of Diatomaceous earth at Pakaraka, Bay of Islands, Auckland. Trans. N.Z. Inst., 1890, XXIII, pp. 375–379. McKay (A.) On a diatom deposit near Pakaraka, Bay of Islands, Auckland. *Op. cit.*, XXV, 1892, pp. 375–377. Inglis (J.) Notes on some of the Diatomaceous deposits of New Zealand. *Op. cit.*, 1882, XV, pp. 340–346, t. 29. Spencer (W. T.) On the fresh-water algæ of New Zealand. *Op. cit.*, XIV, 1881, pp. 297–298. Inglis (J.) On new species of New Zealand diatoms. *Op. cit.*, XIV, 1881, p.p. 357–359, t. 22.

In South Australia we can find no record of true Diatomaceous earths. Mr. G. C. Morris* states that he found fresh-water diatoms in Coorongite, which he describes as a "Diatomaceous mineral," containing about 20 per cent. of hydrocarbons.

Regarding the Queensland occurrences, Mr. W. H. Rands says in his "Report on the Albert and Logan District,"† "Close to Pine Creek, near Selection 31, there is a hill called Meerschaum Mountain, from the fact that a very light white material somewhat resembling that mineral can be picked up on its sides. I have not seen this deposit *in situ*. This substance is an infusorial earth. Mr. W. H. Dixon of Sydney gives the following analysis of it:—

Moisture and traces of organic matter	10·31
Oxide of iron and traces of alumina	0·59
Lime	traces
Silica	89·10
	100·00

Mr. Dixon says that under the microscope the silica is almost entirely composed of the frustules of diatoms—probably *Melosira arenaria*. I confirmed Mr. Dixon's remarks as far as the microscopical examination went."

There seems to be a great resemblance between this earth and that occurring at the Richmond River, also locally known as "Meerschaum."

In Victoria the occurrence of Diatomaceous beds is fairly widespread, and they are of both Tertiary and Post Tertiary age, and of marine or estuarine and fresh water origin. Under the first heading the only deposit we need consider is that occurring near the Yarra, and representing an ancient extension of Port Phillip. From this bed Dr. Coates‡ collected over forty species of Diatoms of the genera *Actinocyclus*, *Coscinodiscus*, *Campylodiscus*, *Stauroneis*, *Navicula*, *Orthosira*, *Pleurosigma*, *Epithemia*, *Synedra*, *Gomphonema*, *Surirella*, and others; as well as foraminifera and shells. As perhaps might be expected in a deposit of this nature the contents comprise species, fresh water, marine, and brackish in habit. Dr. Coates says that this mud dries into a grey coloured substance so friable that it is easily blown away. The part richest in foraminifera, &c., has the fewest diatoms.

This dried substance was mixed with ordinary clay and baked for bricks; but owing to the great contraction induced by heat, this was discontinued. A similar physical property is noted in another part of this paper, in the case of bricks made at Bulli.

In 1857 Mr. William Blandowski§ described extensive deposits of diatomaceous earth in the Mallee Scrub, near Swan Hill, Lower Murray River, Victoria. He describes this as forming "an extensive belt of many miles in length by a width

* Am. Nat., 1877, XI, No. 5, p. 377.
† Folio. Brisbane, 1889. By Authority. Geol. and Pal. Queensland, p. 330.
‡ Procs. R. Soc. Vic., 1860, V, p. 158.
§ On Extensive Infusoria Deposits in the Mallee Scrub, near Swan Hill, on the Lower Murray River, in Victoria, &c. Trans. Phil. Soc. Vict., 1858, pp. 141-146.

of from one quarter to one mile, and a depth of many feet; soft, and a little soapy to the touch." He figures some of these forms, but they are indeterminable from the drawings, with the exception of Fig. 6, p. 142, which, as he says, appears to be an *Eunotia*, comparable to *E. granulata*, Ehrenberg; fig. 3 may be the cross section of a sponge spicule. Some of these sketches (4 and 6) are of specimens from Albury.

Blandowski gives no facts by means of which we can arrive at the age of these deposits, indeed they would appear to be practically recent, and to result from the drying up of extensive chains of shallow pools such as frequently occur in those districts.

Mr. F. M. Krause mentions the occurrence of hollows adjoining basalt being filled with layers of this earth in the Ballarat District.* The same Author gives a detailed account of the Lilicur deposits† and mentions its occurrence at Talbot, and at several places between Clunes and Eddington. The principal deposit in the Lilicur District is that occurring on Allotment 15, Section 1, Parish of Lilicur. The Diatomaceous earth completely fills a hollow in the basalt. It has an area of about four and a half acres, and a maximum thickness of seventeen and a half feet. The deposit has an almost horizontal stratification, and is very uniform in structure and appearance. He also draws attention to the resilicification of portions of the deposit and the formation of patches and bands of common opal. This has been observed in the Wyrallah and Cooma deposits in New South Wales. The specific gravity of the earth is 1·908, and of the common opal 2·008.

Patches of diatomaceous earth occur in a gully leading from the original deposit to Coralulup Creek, and in other places in the district. Two shafts were here sunk about three quarters of a mile from the main deposit, the second of which came across a bed of the earth eighteen inches thick beneath two layers of basalt. Mr. Krause states that the principal forms observed by him were *Pinnularia viridis*, *Navicula*, and *Synedra*, and considers the deposit to be of Upper Pliocene or Pleistocene, lacustrine origin. This is borne out by the additional forms examined by us.

Mr. J. E. Perry‡ in an Australian earth (probably from Victoria), found *Navicula*, *Mastogloia*, *Pinnuluria*, *Cocconema*, *Surirella*. The specimens of *Mastogloia* were undergoing division. It is also recorded from Lancefield and Sebastopol as well as Amherst.§

Professor Kerner von Marilaun in his Natural History of Plants refers to a specimen of Australian Diatomaceous earth in the British Museum as containing a number of species. In reply to a request for information about this specimen,

* Sch. Mines Ballarat, Ann. Rept., 1887, p. 89.
† Trans. R. Soc. Vic., 1887, XXIII, pp. 250–255, map.
‡ Chemist and Druggist, 1895, XLVI, No. 779, p. 426, sketches.
§ Descr. Catal. Rocks Vict. in Indus. and Tech. Mus. Melbourne, p. 127. (8vo. Melbourne, 1894.)

Dr. George Murray has kindly given us the following information:—"The block of Diatomaceous earth comes from a fresh-water deposit, Victoria, Australia. . . . . . . I find in the Catalogue of the Victorian Court, page 200, at bottom of page, "Infusorial earth, from Talbot, exhibited by Mr. Clarence Smith, Mining Surveyor." It is, *possibly*, our specimen (Dr. Murray had previously stated that he believed the specimen had been obtained by a dealer from the Colonial Exhibition). The species of diatoms found in it are—

Cymbella turgidula, *Grun.*
Stauroneis phœnicenteron, *Ehrb.*
Navicula major, *Kütz.*
„ tenella, *Breb.*
„ commutata, *Grun.*
„ subcapitata, *Grey.*
Gomphonema dichotomum, *W. Sm.*
„ subramosum, *Kütz.*
„ subclavatum, *Grun, var.*
Achnanthes gibberula, *Grun.*
Cocconeis lineata, *Grun.*
Epithemia gibba, *var.* ventricosum, *Grun.*
Eunotia lunaris, *Grun.*
„ arcus, *Ehrb., var.* hybrida, *Grun.*
Synedra ulna, *var.* danica, *Kütz.*
„ „ *var.* subæqualis, *Grun.*
„ „ *var.* bicurvata, *Grun.*
„ oxyrhynchus, *Kütz.*
„ tenera, *W. Sm.*
Fragilaria virescens, *Ralfe.*
„ „ *var.* exigua, *Grun.*"

In the collection of the Mining and Geological Museum there are Diatomaceous earths from Eglinton, Amherst, Belfast, Coralulup Creek, Splitter's Creek, Talbot, and Rodborough. Of most of these we can give no stratigraphical information, but there is a most marked resemblance between their contents. The more common forms are—*Diatoma, Cocconeis, Navicula, Melosira, Synedra, Eunotia, Tabellaria, Stauroneis, Epithemia, Cymbella, Achnanthes?, Eccyonema?, Suririella, Fragillaria.*

A species of *Diatoma* has been seen in the earths from Eglinton, Amherst, Belfast, Coralulup Creek, Splitter's Creek, and Rodborough. This appears to be *Diatoma vulgare*, Bory. Some of the forms seem to approach nearer to *D. anceps*, Ehrenberg, one of the species of *Diatoma* forming the subgenus *Odontidium*, The first-mentioned species forms a zigzag filament, and is finely costate, whereas the second form is composed of frustules, coarsely costate, and forming short filaments. The first-mentioned is much more common in the slides we have examined.

One species of *Cocconeis* occurs in all the earths examined. Of the species diagnosed by Dr. Van Heurck* the one to which our species bears most resemblance is *C. pediculus*, Ehrenberg, stated to be common everywhere in fresh or brackish water.

That very common form *Navicula* occurs also in all the deposits. In general form and structure it appears to approach nearest to *N. nobilis*, Ehr., in all except size, so that probably it is closely allied to the variety *gentilis*, of which Van Heurck says it may be considered to be a dwarf form.† There is another species of *Navicula* present, allied to *N. gastrum*, Ehren. In fact it is probable that several other species are present, but the variations are so great that we consider it better to name only the more common and well-marked forms.

In the earth from Eglinton and Talbot occur *Stauroneis*, allied to *S. phoenicenteron*, Ehrenberg, which is like a *Navicula* in outline and ornamentation, but possesses a well-marked stauros.

A small species of *Melosira* has been observed in the Eglinton, Amherst, Belfast, and Splitter's Creek earths. It appears to differ slightly from the New South Wales species, but chiefly in size. It will be referred to later on.

Synedra ulna occurs, in some cases abundantly, in all the earths, more especially at Coralulup Creek.

A *Eunotia*, allied to *Eunotia gracilis*, also occurs in all the earths examined by us.

Tabellaria, cf. *fenestrata*, Lyng., is fairly common at Belfast, Coralulup, and Splitter's Creeks, and we think we observed it in the Eglinton deposit.

Epithemia also occurs at Eglinton, Splitter's Creek, and Rodborough, and possibly at Belfast, at which *Fragillaria* is also very abundant.

Cymbella, the term which Van Heurck uses instead of *Cocconema*, occurs in all the Victorian, though only one specimen has been observed in the Talbot earth.

Doubtful specimens of *Gomphonema* were observed in the Coralulup and Amherst deposits. In the Rodborough earth *Eccyonema* cf. *prostratum*, Ralfs was seen. Forms allied to *Achnanthes* and also to *Campylodiscus* also occurred.

The *Spongilla* spicules closely resemble those occurring in the New South Wales earths, a description of which will be found later on.

NEW SOUTH WALES.

Cooma.—For the following description of these deposits we are indebted to the kindness of Warden John H. King. The deposit "is situated about five miles from Cooma and one and a half from Bunyan Platform. It occurs in a hollow

* *Op. cit.*, p. 287.
† *Op. cit.*, p. 165.

partly surrounded by basalt hills. The surface is treeless and grassless, and the deposit is covered with about three inches of red earth and pieces of white quartz. The depth of the deposit is not known, as it has only been sunk on for sixteen feet. It is over a chain wide by six chains long exposed to view, and then occurs in the bottom of a gully about four feet deep. There is no doubt a large area of it, but deeply covered with soil." In this gully loose on the soil are pieces of red common opal. In thin sections under the microscope a translucent clouded field, dashed with black, red, and yellow blotches is seen, enclosing angular crystalline grains in places. By reflected light it is mainly red. With a ¼-inch objective the field is seen to contain comminuted fragments of diatoms, chiefly, if not altogether, frustules of *Melosira*, just as in the case of the diatomaceous earth itself. It is very evident that, as in the case of the Wyrallah deposits referred to later on, the common opal is caused by a deposit of colloidal silica cementing portions of the earth into a homogeneous siliceous mass. The deposit is a thick one, as proved by its being sunk upon to a depth of twenty feet, and then not bottomed. Three analyses of this earth have been made in the Departmental Laboratory. On reference to the tabulated results on page 132 it will be seen that the percentage of silica (moisture neglected) is remarkably uniform—a little over 88 per cent. Two of the analyses show the presence of appreciable quantities of iron, indeed the Cooma earth generally becomes yellow on calcination. The high percentage of carbonates of the alkaline earths in one of the analyses is noticeable. It would indeed seem as if these salts must have resulted from accidental impurities in the earth.

This deposit appears to be of a greater extent and purity than any other as yet known in New South Wales.

Leaf impressions are said to occur here, but up to the present no opportunity has offered itself of obtaining specimens. The existence of black bands, bleaching on exposure, is said to have been noticed.

Microscopically the earth is composed almost entirely of *Melosira*, similar to those occurring in other New South Wales deposits, and well developed *Spongilla* spicules. These will be referred to later on.

Wyrallah.—The deposits on the Richmond River appear to be typically developed at Wyrallah, nine miles from Lismore. Here there seems to be a number of scattered deposits on either side of the Richmond River. They are surrounded and overlain by scoriaceous basalt, and occur in depressions in the same rock. Probably large areas of the Diatomaceous earth have been washed away. It has been stated at various times that considerable thicknesses of the earth exist on private lands, but this requires confirmation.

The physical character of the diatomaceous earth from these deposits is peculiar. It is hard and stony, requiring considerable pressure to crush it, and of a dirty white colour. The percentage of silica is high—over 90 per cent., and the lower portion of the deposit merges into a band of yellowish common opal, about a foot thick. Pieces of the opaline rock are marginally earthy, due probably to the removal by solution of the secondary silica, as in the case of chalk flints. The rock is isotropic, and marked with parallel bands, coloured by splashes of yellow and brown. With a high magnifying power the base is seen to be made up of hazy wisps and shreds, and numerous indistinct fragments of *Melosira.* This has been remarked on by the Rev. J. Milne Curran.* The opal is an intrinsic part of the deposit owing its compactness and homogeneity to the deposition of secondary silica. The percentage of substances other than silica is low. The high percentage of silica in diatomaceous earths is sometimes regarded as a point in their favour, but this must be accepted with great caution. In this case, and also in others, a proportion of silica is due in part to secondary silica, which would not only be of little use in itself for those purposes to which tripolite is put, but also renders the material hard and stony, necessitating crushing as above mentioned.

Granting the possibility of large quantities existing here, it is very doubtful whether this earth will ever receive much attention.

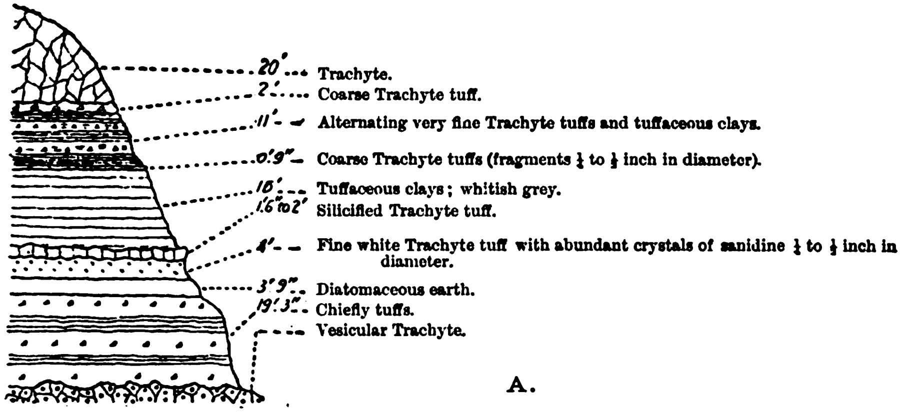
Fossil leaves are of frequent occurrence in this earth, known locally as meerschaum. The late Baron von Mueller has described, probably from this deposit, *Liversidgea oxyspora*, fronds of a species of *Pteris*, and portions of leaves, perhaps of *L. oxyspora.* †

Referring to a deposit from the Richmond River, described as "cimolite," by Professor Liversidge,‡ Professor David says, "there can now be little doubt that this material . . . . . must graduate into a clayey diatomaceous earth, as diatoms in some numbers have been observed by me in a similar rock from the same locality."†

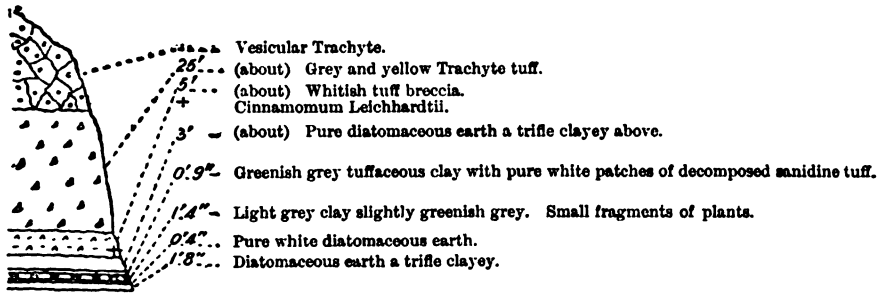
Warrumbungle Mountains.—This deposit has already been described by Professor David.|| There are two out-crops at the bottom of the Wantialable Creek Gully. The bed of diatomaceous earth, three feet nine inches thick, occurs interstratified with a series of trachytic rocks. It is overlain by a remarkable series of trachytic tuff, and overlies another similar bed. A leaf referred to *Cinnamomum Leichhardti*, Ett., was found in these tuffs. Professor David considers that they are of early Eocene or late Cretaceous age. As will be seen by the following section of the ridge, near the base of which the deposit occurs, we have first a trachyte sheet

* Jour. R. Soc. N.S. Wales, 1897, XXX, p. 258.
† Jour. R. Soc. N.S. Wales for 1876 [1877], p. 240.
‡ Journ. R. Soc. New South Wales for 1876 [1877], X, p. 239.
§ Procs. Linn. Soc. N.S. Wales, 1896, XXI, p. 262.
|| Procs. Linn. Soc. N.S. Wales, 1896, XXI, Pt. 2, pp. 261-261, t. 15-17.

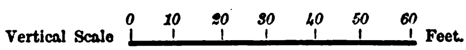
twenty feet thick, then trachyte tuffs of various conditions for about thirty-six feet, then the diatomaceous earth three feet nine inches, nineteen feet of tuffs, and then trachyte again. The tuff immediately above the earth contains numerous sanidine crystals.



A.



B.



A. Section showing intercalation of Diatomaceous Earth in the trachyte series, Warrumbungle Mts.

B. Section showing association with *Cinnamomum Leichhardti*, Ett. These sections are, by kind permission of the Linnean Society of N. S. Wales, reproduced from Procs. Linn. Soc., N. S. Wales, 1896, xxi, pl. 16.

Some interesting notes on the general geology of the Warrumbungle Mountains will be found in an old report by Stutchbury.* It is possible he may have seen the diatomaceous deposits as he makes mention of a large portion of Keewang Swamp being "composed of a very light cream coloured deposit," and later on "a well sunk at Fisher's, in the valley of the Welleborowong Creek, exhibits the same light chalky clay as that at Keewang, also containing plants." He attributes the origin of these to decomposed trap rocks.

* Papers relating to the discovery of gold, Parl. Papers, Feby., 1854, p. 9. (Fol., London, 1854.)

Referring to the remarkable and frequent association of diatomaceous earth with volcanic rocks, Professor David suggests that this is not fortuitous. "The superheated water flowing from hot springs and from the lavas themselves during the eruptions would be certain to carry more or less silica in solution, and its high temperature, combined with its dissolved silica, would probably render it a very favourable medium for the development of diatoms to the exclusion of most other kinds of plants."

Two analyses have been made by the Department (see table, p. 132). One of these showed the presence of no less than 10 per cent. of carbonate of lime. Iron and alumina are not exceptionally high, and silica reaches nearly 90 per cent. in the original analysis. There is some reason for thinking that some at least of the reported discoveries of tripolite in the Dubbo district are traceable to this deposit.

There would appear to be no probability of these deposits, as at present known, being of commercial importance.

Slides of this earth have been examined and are found to consist mainly of *Melosira* and *Spongilla* spicules; rare evidences of the occurrence of a naviculoid genus were also observed. Mr. Etheridge has reported* on this earth to some length, and little can be added to his remarks. He recognised as its constituents *Melosira*, cf. *orichalcea* and *Spongilla*. Further reference will be made to these forms.

Barraba.—This deposit has been described† by Mr. E. F. Pittman, Government Geologist. It occurs in the Nandewar Range, ten or twelve miles south-west of Barraba. Here the slates are overlain by basalt, forming a flat tableland. On this tableland there is, under the basalt, a large deposit of pure diatomaceous earth, attaining a thickness of at least eight feet, having a layer of coarse sand two inches thick about three feet from the top. It is probable that the entire series is forty or fifty feet thick, but this needs an exhaustive examination to prove it. It rests on a bed of sandy mudstone about a foot thick, under which is an impure deposit of diatomaceous earth containing rolled pebbles and fragments of interbedded lava. According to an analysis made by Mr. W. H. Dixon it contains 80·56 per cent. of silica, and has a specific gravity of 1·21; it is of a dead white colour, with black specks. More recently Mr. Pittman revisited the deposit and collected leaves of *Eucalyptus* and other plant remains from the associated beds. The bed above the earth is light coloured, and contains plant remains and also numerous sanidine crystals. These beds are apparently tuffaceous, fine grained, harsh to the touch, buff coloured, and to some extent calcareous. The floor of the deposit is also apparently tuffaceous, fine grained, and of a yellow brown colour. The

* Ann. Rept. Dept. Mines N. S. Wales for 1887 [1888], pp. 165–166; *Ibid.*, for 1888 [1889], p. 190.
† Ann. Rept. Dept. Mines N. S. Wales for 1881 [1882], p. 142.

series rests unconformably on or in a denuded hollow of the Gympie claystones, which Mr. Pittman found to contain, here, *Lepidodendron australe*, McCoy. Locally it is used as raddle.

Three analyses have been made by the Department. The highest percentage of silica is 80·56 (not allowing for moisture). All the analyses, two in particular, indicate the presence of much iron and alumina; the latter must exist as silicate in the form of clay so that the percentage of available silica should be accordingly reduced. Carbonates of lime and magnesia are always present, occasionally in considerable quantity. Were this deposit to be used commercially, which its distance from rail renders improbable at present, its value would be reduced by the presence of the clay and the lower percentage of silica. The basalt overlying the tripolite is compact in texture and quite fresh. It is of a variety fairly rich in olivine, with the augite and plagioclase ophitically grouped; magnetite is present as is usual in such rocks. The unaltered condition of the constituents, more especially of the olivine, testifies to the recent age, geologically speaking, of the basalt.

This is probably the deposit referred to by Professor Liversidge* as being "forty miles from Tamworth."

This earth contains *Melosira* and *Spongilla* spicules in abundance.

Other Deposits.—Numerous other small deposits occur in New South Wales of which we have no stratigraphical information, and in many cases their exact position is uncertain. Deposits said to occur at Newbridge, Blue Mountains, Mudgee, Coolah, Wellington District, Bathurst, Cungen, Tweed River, Bello Mountain near Cobbadah, are similar in being composed of *Melosira* and *Spongilla* spicules. One specimen from Newbridge contains in addition a Naviculoid genus. The richest earth, in point of contents, with which we are acquainted from New South Wales is one said to come from Paddy's River, Shoalhaven. This is a dirty white earth, and contains the common species of *Melosira* (? *arenaria*), *M. Jurgensi*, *Navicula*, *Cymbella*, and *Spongilla*. The *M. Jurgensi* does not occur, as far as we are aware, in any of the Victorian earths that have passed through our hands. The *Navicula* and *Cymbella* are similar to Victorian forms.

As regards the common New South Wales *Melosira*, there appear to be two well-marked varieties, which Mr. Etheridge, in his report before quoted, speaks of as *sp. a* and *b*. The species proper he referred to *M. orichalcea*, Smith; but, according to Van Heurck, this is the *M. crenulata* of Kützing.†

In some specimens there is evidence of denticulation along the margin, though more commonly it is plain. There are in general two marked varieties, one much

* Minerals of New South Wales, p. 177. (8vo. London, 1888.)
† Op. cit. p. 443.

narrower than the other. The two forms, as figured by Van Heurck, to which our New South Wales forms approach nearest, are *M. arenaria* and *M. granulata*, and in the coarseness of the ornamentation there is a closer approach to the latter. It is probable that the variation in length and breadth and the slight difference in coarseness of the punctation and striation is only individual, and we may consider our form to be *Melosira granulata*, Ehrenberg.

Regarding the *Spongilla* spicules nothing we think can be added to Mr. Etheridge's remarks on them. He describes them as long, slightly curved, pointed at both ends, and in some cases serrated. The axial canal is well preserved. Numerous instances of these spicules in all conditions have come under our notice. Mr. Etheridge referred all these spicules to the genus *Spongilla*.* Dr. G. J. Hinde, the eminent spongiologist, confirms Mr. Etheridge's opinions and adds that he saw amphidiscs which pointed to the occurrence of *Meyenia* also. The possibility of this occurrence was noted by Mr. Etheridge who did not consider he had sufficient evidence to settle the point.

Both *Spongilla* and *Meyenia* occur in Australian fresh waters.

General Summary.

From the evidence brought forward it will be seen that the stratigraphical relations, as well as their contents, point to the fresh-water origin of the New South Wales, Victorian, and Queensland diatomaceous earths, with the exception of the Yarra deposit. It will also be seen that they cannot compare in extent with those in some other countries, notably America. Their purity is to some extent inferior, and in many instances the comminuted character of the diatom tests, while perhaps favourably affecting their polishing capabilities, will tend to lessen the absorbent power. They appear to belong approximately to the same geological age, and that a late Tertiary. In the case of the Warrumbungle deposit Professor David considers the associated trachytic rocks to be of late Cretaceous or early Tertiary age. It may further be noted that the deposits in many cases owe their preservation to the basaltic or trachytic sheets by which they are or have been covered, having been thereby protected from denudation which would have inevitably swept away such soft deposits. An association with peaty material has been noticed elsewhere (Scotland), but this condition, as might be expected, does not obtain in Australia where true peat is unknown, the late Tertiary climate of Australia being unfavourable to its formation.

We have to express our indebtedness to Professor Wilson of the University of Sydney, for the loan of his microphotographic apparatus, and also to Mr. Robert Grant for the preparation of the microphotographs, some of which are reproduced on Plates XII–XV.

* Ann. Rept. Dept. Mines, New South Wales, for 1887 [1888], p. 166.

PLATE X.

Pecopteris ? obscura, *Dun.*

Fig. 1. Specimen showing mode of growth, and arrangement of secondary pinnæ.

Fig. 2. Fragment of a pinnæ, showing one of the pinnules in a condition which may be fructification.

Sphenopteris Carnei, *Dun.*

Fig. 3. Specimen showing incision of pinnules.

Drawn from nature by Mr. F. R. Leggatt.

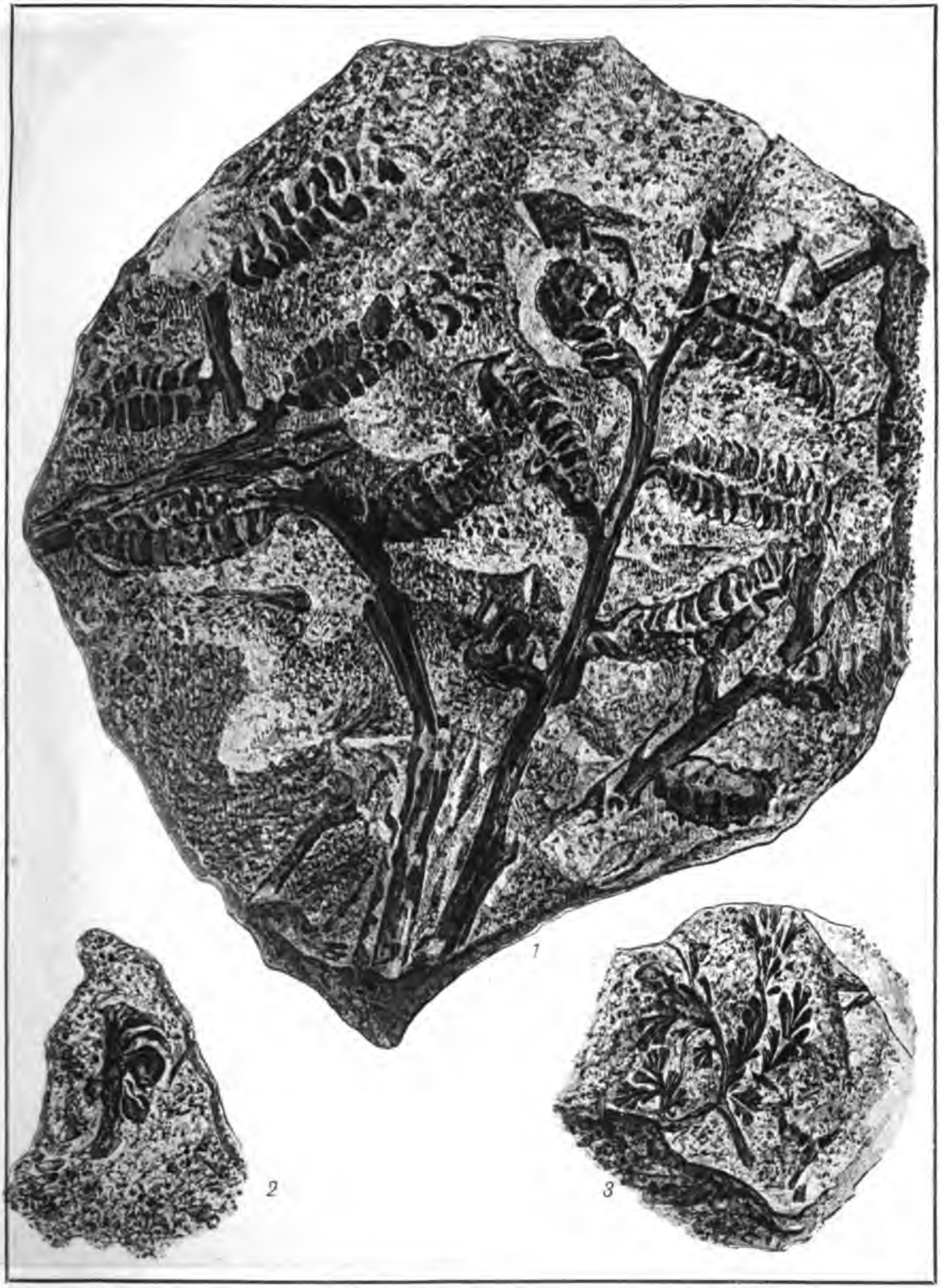

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PLATE XI.

Archæopteris Howitti, *McCoy.*

Fig. 1.—Specimen showing two pinnæ.
Fig. 2. Portion of pinnæ, enlarged.
Fig. 3. Do do do

Sphenopteris Carnei, *Dun.*

Fig. 4. Specimen showing lobate and entire condition of pinnules.
Fig. 5. Pinnules enlarged.

Pecopteris ? obscura, *Dun.*

Fig. 6. Portion of pinnæ, showing retracted apices of the pinnules.
Fig. 7. Portions of pinnæ.

Cordaites australis, *McCoy.*

Fig. 8. Stem, basal portion, which probably belong to this species.

Drawn from nature by Mr. F. R. Leggatt.

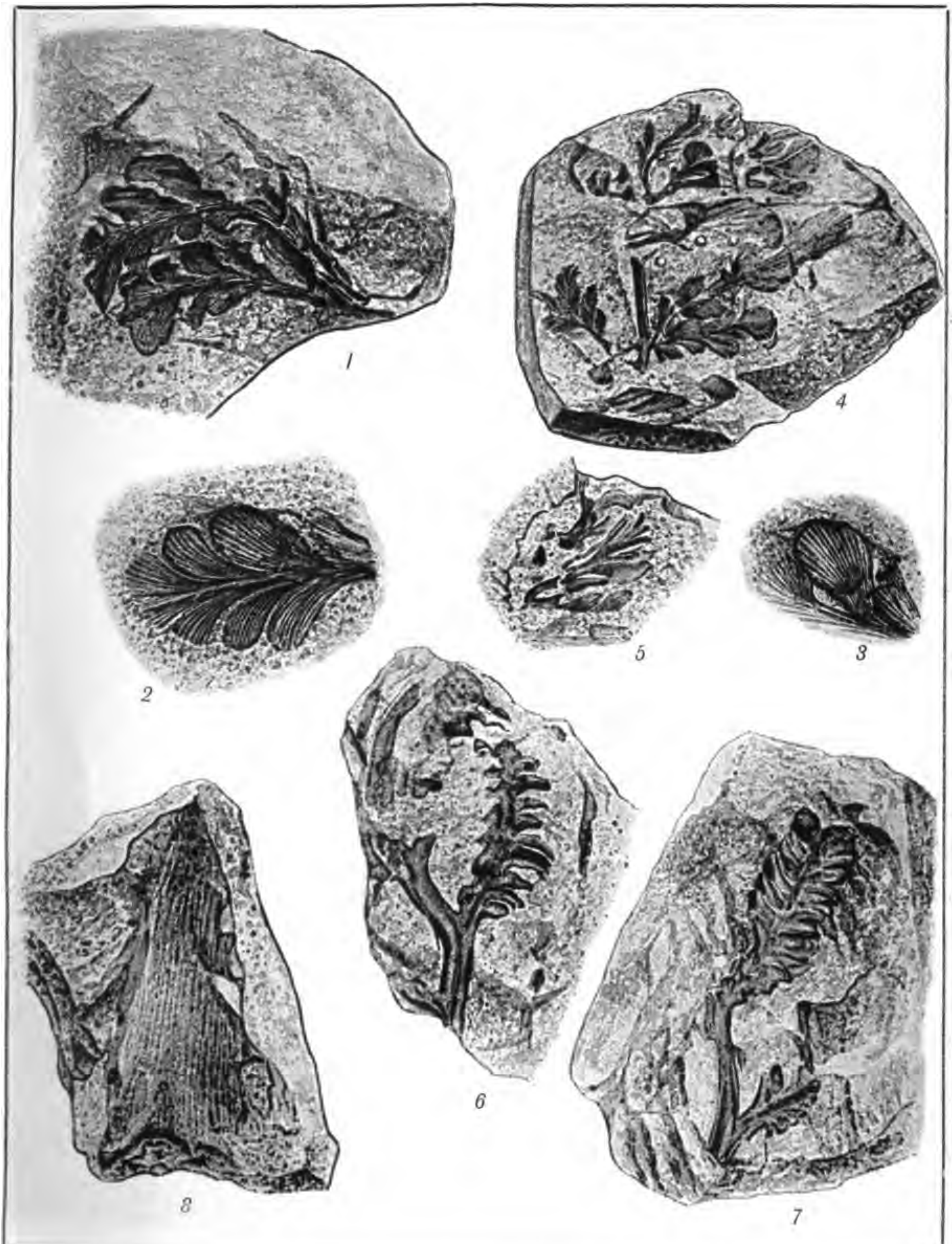
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PLATE XII.

Microphotograph of Cooma Diatomaceous Earth, showing acerate *Spongilla* Spicule and two forms of *Melosira*.

Photographed by Mr. Robert Grant, of the Medical School, Sydney University, with Beck's $\frac{1}{8}$ and Zeiss' No. 2 prg. oc. at 105 cm. = 400 diameters.

PLATE XIII.

Microphotograph of Diatomaceous Earth from Coralulup Creek, Victoria, showing *Navicula, Cocconeis, Synedra.*

Photographed by Mr. Robert Grant, Medical School, Sydney University, with Beck's $\frac{1}{6}$ and Zeiss' No. 2 prg. oc. at 105 cm. = 400 diameters.

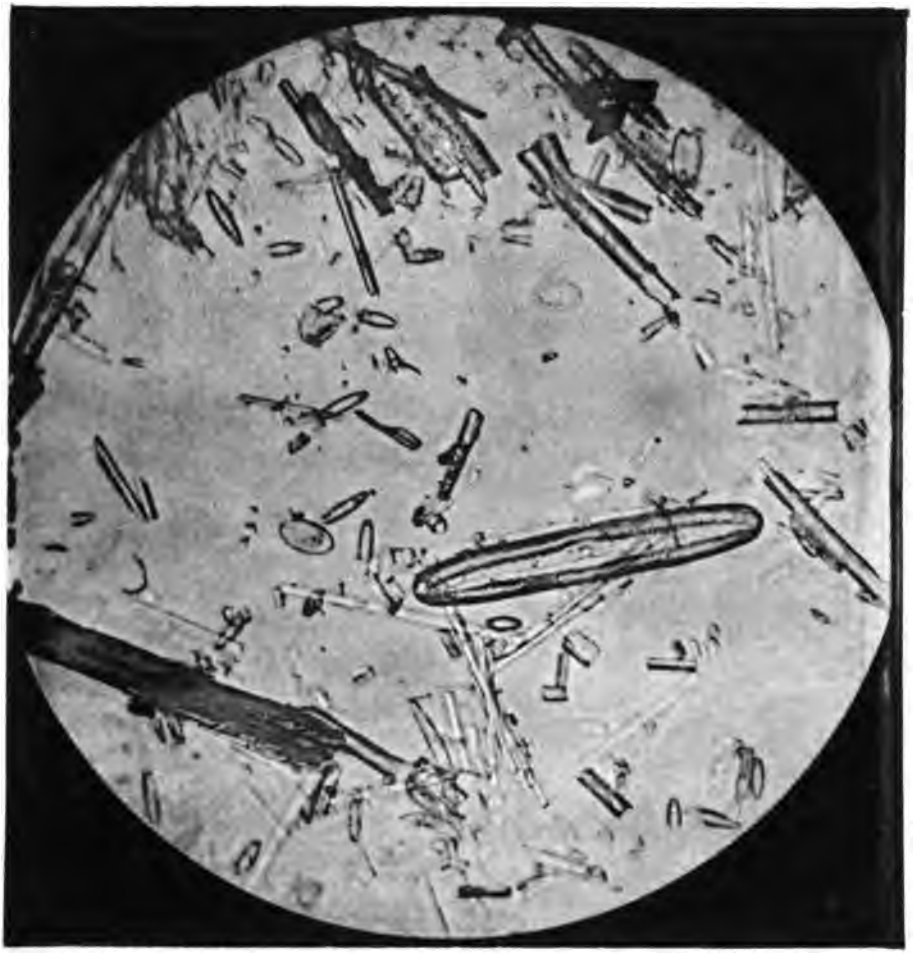


PLATE XIV.

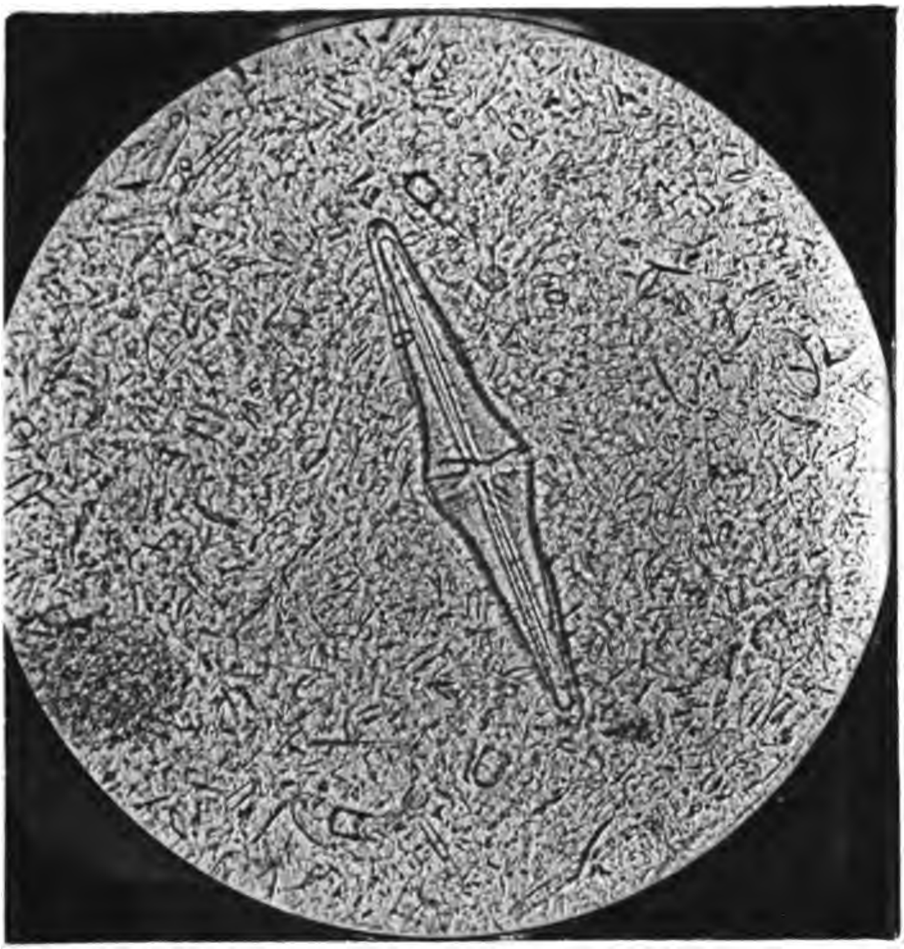
Microphotograph of Diatomaceous Earth from Coralulup Creek, Victoria, showing *Synedra* cf. *ulna*, Ehr., *Navicula*, and *Cocconeis*.

Photographed by Mr. Robert Grant, Medical School, Sydney University, with Crouche's $\frac{1}{10}$ and Zeiss' No. 2 prg. oc. at 105 cm. = 800 diameters.

PLATE XV.

Microphotograph of Diatomaceous Earth from Eglington, Victoria, showing *Stauroneis*, cf. *phœnicenteron*, Ehr.

Photographed by Mr. Robert Grant, Medical School, Sydney University, with Beck's $\frac{1}{6}$ and Zeiss' No. 2 prg. oc. at 105 cm. = 400 diameters.



DEPARTMENT OF MINES AND AGRICULTURE, SYDNEY.

RECORDS

OF THE

GEOLOGICAL SURVEY OF NEW SOUTH WALES.

Vol. V.] February, 1898. [Part 4.

XXII.—A New Form of *Syringopora*, allied to *Syringopora tabulata*, Van Cleve: by R. Etheridge, Junr., Curator of the Australian Museum, Sydney.

[Plate XVI.]

The Coral about to be described—*Syringopora bellensis*—is one out of many excellent instances that exist of Australian fossils displaying a very marked structural affinity with an allied form in some other part of the world. In this case it is with *Syringopora tabulata*, Van Cleve, from the Upper Helderberg Group of North America. The specimen is unfortunately imperfect, having been fractured across the middle at right angles to its growth, leaving only the upper portion of the colony (Pl. XVI, Fig. 1), now measuring three by two and a half inches. In its present condition it is sub-hemispheric, with the corallites arranged in an irregularly fasciculate manner. They are cylindrical or tubular, and more or less circular, as is usual in *Syringopora*, with an average diameter of one-sixteenth of an inch. The mouths are sharp and unexpanded, but here and there the actual periphery of the calice is rather less in diameter than the corallite in general, giving to it a slightly contracted appearance; at other times there is an inwardly bevelled margin, giving rise to a kind of outward area, or vestibule, that is always devoid of septa (Pl. XVI, Fig. 3); but when the calice margins assume their normal character the septa extend to the very edges (Pl. XVI, Fig. 4). The distance apart of the corallites at the upper surface of the colony is variable; there may be a cluster of several, even united by their walls, or only two so joined, but their

normal condition is a union with one another only by the mural expansions shortly to be noticed; thus the interstitial surface between contiguous corallites is of very uncertain and variable extent. They are surrounded by a concentrically wrinkled and annulated epitheca, the annulations being placed at unequal distances apart (Pl. XVI, Fig. 5).

Tubular connecting processes, in the usual acceptance of the term, do not exist, but their place is taken by a series of mural expansions in the same plane, completely investing the corallites. The result is that, when viewed from above, the upper ends of the corallites seem to be protruding through a shield or platform, existing at the same level all over the colony (Pl. XVI, Fig. 1). Here and there, however, the lateral extension of this expansion is limited to surrounding a few corallites, the regular succession of the mural expansions in a vertical view being thus more or less interrupted. The surface of these investments bears only here and there a few concentric wrinkles around the corallites; and although of no great thickness, they are, as will be subsequently shown, hollow, and are composed of extensions of the corallite walls. Speaking of these in *S. tabulata*, Van Cleve, Prof. Alleyne Nicholson says* that the mere external resemblance to that of *Tubipora* is very striking.

The septa (Pl. XVI, Fig. 4) are visible on the walls of the calices with an ordinary lens as vertical rows of fine, slender spines of no great length. It is difficult to estimate the number of rows, but they are very numerous, are quite of the Favositiform type, spiniform and never lamellar. Nicholson says† that the larger species of *Syringopora* seem to have as many as twenty rows, but in the present species they are much more numerous than this.

Wherever the corallites are, from the nature of their growth, brought into close contact with one another, no trace of mural pores is to be seen; indeed, according to Nicholson,† these structures have not been observed in *Syringopara*, but their place is taken by exothecal connecting processes, here represented by the platform-like mural expansions. Schlüter, however, has described‡ a Devonian *Syringopora* (*S. tenuis*, Schlüter), in which the walls, wherever two corallites come in contact, are pierced by mural pores, and he figures a portion of an open corallite without tabulæ, with three mural pores one above the other.

The walls of *Syringopora* are said§ by Nicholson to consist of two layers—an outer, light-coloured, dense stratum of indistinctly fibrous or granular sclerenchyma, and an inner, darker, and laminated or fibrous ring. In a horizontal thin section

* Proc. R. Soc. Edinb., 1880–81, XI, No. 108, p. 224.
† Proc. R. Soc. Edinb., 1880–81, XI, No. 108, p. 224.
‡ Abhl. Geol. Specialkarte Preuss.—Thür. Staaten, 1889, VIII, Heft 4, p. 171, t. 16, f. 4.
§ *Ibid.* p. 225.

prepared for the microscope the same compact walls are visible in *S. bellensis*; but the character of the two layers seems to be reversed. The peripheral layer is dark and apparently fibrous, the inner very light in colour and laminated, or fibrous-laminar. The septa, where seen around the edges of the visceral chambers, are of the nature of thorn-like spines, slender and moderately long, but both in horizontal and vertical sections they are of the same dark colour as the outer portions of the walls, and are enveloped in the inner and lighter coloured ring, through which they protrude. As it is very seldom that the horizontal section cuts the corallites precisely at right angles, we observe many of the septa as scattered dark dots. In vertical sections these occupy their normal position in vertical rows; but according as the section under examination is taken exactly in the plane of the corallites, or a little obliquely, so will the amount of the septa be individually apparent.

The cut edges of the invaginated tabulæ (Pl. XVI, Figs. 7–9.) are closely packed in *S. bellensis*, and by their frequent and apparent anastomosis produce a vesicular effect, the vesicles both in a horizontal and longitudinal section appearing to be unusually long and narrow, the upper surface of these tubular vesicles in a vertical section being gently convex and inclined downwards. I have not observed any horizontal tabulæ whatever, although such are stated* to sometimes exist in *Syringopora*, nor the slightest trace of septa on the inner surfaces of the descending tabulæ, another feature "not uncommonly" met with in the genus.†

The cylindrical tube (Pl. XVI, Fig. 6.) formed by the union of the funnel-shaped tabulæ, and usually stated to be central, is in the sections before me, either in this position or excentric; but the latter may possibly be exaggerated by the direction taken by the section, for in some corallites it isround, in others oval, but in all large. The tube is in places tabulate (Pl. XVI, Fig. 8.), the tabulæ being very fine, close, and concave, and some of them at least seem to be inward prolongations of the larger invaginated tabulæ. Such occurs in other species of *Syringopora*.‡

The connecting floors, whether viewed in horizontal or longitudinal section, are hollow, like the connecting processes of other species of *Syringopora*, and are to some extent filled with anastomosing endothecal tissues, generally prolongations of the tabulæ. A vertical section exemplifies how very much these floors vary in thickness and in their distance apart from one another in successive tiers.

The genera *Cannapora*, Hall, *Thecostegites*, Ed. and H., and *Chonostegites*, Ed. and H., as well as *Syringopora tabulata*, possess similar mural expansions to those

* Nicholson, Tab. Corals Pal. Period, 1879, p. 211.

† Nicholson, Tab. Corals Pal. Period, 1879, p. 212.

‡ Nicholson, Proc. R. Soc. Edinb., 1880–81, XI. No. 108, p. 224.

just described; and it is, therefore, necessary to briefly refer to them. First, as to *S. tabulata:* The description* of this coral by the distinguished authors, Edwards and Haime, was confined chiefly to its external features; but they laid stress on the mural expansions. Dr. Rominger amplified† this description, and described the mural expansions as verticillate, "by the lateral anchylosis of which almost uninterrupted laminar floors are formed." Our coral, although closely allied to *S. tabulata*, differs essentially in the diameter of the corallites, the general size of the corallum, and in the largely increased number of rows of septal spines. Possibly, were more known of the internal structure of the American coral, a further divergence could be pointed out.

In the case of *Cannapora*, we are again indebted to Rominger for a fuller description‡ than the meagre details originally given by Hall.§ After alluding to the special peculiarity of the floors, he adds that the calice mouths are inflated, the septa spiniform, but the tabulæ direct and horizontal, not infundibuliform; and where the corallites come in contact the walls are poriferous. Nicholson remarks that the chief distinction between *Cannapora* and *Syringopora*, and therefore equally between the former and our coral, seems to consist in the presence of those horizontal instead of infundibuliform tabulæ. On the other hand, the late Prof. Ferdinand Roemer stated that the tabulæ are seldom visible in *Cannapora*‖; but as Drs. Nicholson and Hinde have described¶ a second species of the same genus, in which the tabulæ are "well developed" and horizontal, there can, I think, be little question of their nature.

Thecostegites possesses much the outward appearance of *Syringopora tabulata* and *S. bellensis*, with the same exothecal expansions; but horizontal tabulæ are present, a point on which Nicholson,** Zittel,†† and Roemer‡‡ agree. If so, *Thecostegites Bouchardi*, and *Syringopora tabulata* cannot be the same, a point already brought forward by Roemer,§§ and for the same reason our *S. bellensis* is not a *Thecostegites*. I do not find any mention of true mural pores in the latter, not even to the same extent as in *Cannapora*. Edwards and Haime distinctly state‖‖ that there was communication between the corallites, whilst Roemer is silent on the matter. Nicholson remarks¶¶ that in *Thecostegites* the periodic floors are, as in *Chonostegites*, so far exothecal that they are hollow expansions from the walls of

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* Archiv. Mus. Hist. Nat., 1851, p 288 t. 15 f. 3 *a* and *b*.
† Report Geol. Survey Michigan. Lower Peninsula, 1876, Pt. 2, p. 84.
‡ *Loc. cit.*, p. 86.
§ Pal. N. York, 1852, II, p. 43.
‖ Lethaea Palaeozoica, 1883, Lief. 2, p. 498.
¶ Pal. Ontario, 1875, II, p. 58.
** Tab. Corals Pal. Period, 1879, p. 205.
†† Traité Pal.-I. Paléozoologie, Pt. 1, 1883, p. 243.
‡‡ Lethæa Palaeozoica, 1883, Lief. 2, p. 499.
§§ *Ibid.*, p. 490.
‖‖ Archiv. Mus. Hist. Nat., 1851, V, p. 297.
¶¶ Palæontology, 3rd edit., 1889, I, p. 322.

the corallites, and filled with prolongations of the endothecal tissues of the corallites themselves. The same language might also be applied to the form now under consideration.

Lastly, as to *Chonostegites.* The appearance and mode of growth of the latter and *S. bellensis* closely resemble one another, even to the annulation of the corallites, as well as the periodic expansions. Wherever the walls of contiguous corallites come in contact, the former become pierced by mural pores, as in *Cannapora.* The tabulæ are arched, "often uniting with one another in such a way as to give rise to a loose and open subvesicular tissue, which is continued into the hollow periodic expansions of the corallites."* This produces, in longitudinal sections, a totally different appearance to that seen in *S. bellensis*, the lenticular cells of the one, produced by the inosculation of the tabulæ, being quite different from the highly inclined vesicles formed by the infundibuliform tabulæ of the other. In *Chonostegites* the surfaces of the tabulæ are septate, but I have not observed this in *S. bellensis.*

This interesting form is from the Siluro-Devonian Limestone of Wellington, New South Wales, and is contained in the collection of the Geological Survey of New South Wales. The River Bell, after which it is named, passes in front of the limestone escarpment containing the Wellington Caves.

XXIII.—Saddle Reefs at Hargraves: by J. ALEX. WATT, M.A., B. Sc., Geological Surveyor.

I.—Introduction.

HARGRAVES, a once prosperous mining township, is situated on Louisa Creek, a tributary of Meroo Creek, and is distant fifteen miles in a direct line south-west of Mudgee, but twenty-four by the coach road, and about one hundred and twenty-eight miles (as the crow flies) north 35° west from Sydney.

During a recent visit to this township, I had an opportunity of making a hurried examination of certain reefs that were being worked not more than a few hundred yards westerly of the post office.

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* Nicholson, Tab. Corals Pal. Period, 1879, p. 152.

Before proceeding to describe the reefs, I have much pleasure in acknowledging my indebtedness to Mr. Spratt, not only for his kindness in conducting me over the ground and through the workings of the mine in which he is interested, but in communicating to me his opinion, with the evidence on which it was based, that the ore bodies were of the nature of saddle-reefs. Before my examination had proceeded far, I was able to thoroughly endorse this opinion, and to offer certain suggestions, based on this theory of their nature, with reference to the course future prospecting operations should take.

Saddle-reefs may be described as saddle-shaped bodies of quartz filling cavities in the anticlines and synclines (especially the former) of folds, in which the reef material conforms to the strike and dip of the enclosing strata. They occur in sharply folded sedimentary rocks, the constituent beds of which, in the process of bending, have opened out, often along the junction of two kinds of rock, *e.g.*, at the junction of slate and sandstone at Bendigo. By this means cavities are produced both in the anticlines and synclines of the folds, the greatest amount of separation of the strata usually taking place in the neighbourhood of the "centre country," and perhaps more frequently in the upper beds of the anticlines than elsewhere.

Saddle-reefs consist of three parts, known as the "cap" and the two "legs," the former, in true saddle reefs occurring in anticlinal arches, being the upper flat-lying portions, while the latter are the steeply-dipping lateral extensions which gradually pinch out as they are followed from the cap.

This variety of deposit is, as far as our present knowledge goes, confined to Australia. The most typical examples, and those to which the name was first applied, occur at Bendigo, in Victoria, where reefs of this description are very numerous and of very great economic importance. These have been described by Mr. T. A. Rickard,* and more recently by Mr. E. J. Dunn.†

In New South Wales the celebrated Broken Hill lode has been described by Mr. Pittman‡ as a deposit which fills a more or less saddle-shaped space produced by the folding of gneiss. This view was adopted by Mr. Jaquet in his Memoir on this lode,§ where sections through several of the shafts are given showing the division of the lode at varying distances from the surface into two branches by what he believes to be the "centre country" of an anticlinal fold.

* Trans. Am. Inst. Mining Eng., 1892, xx pp. 463–545.

† Dept. Mines Vict., Reports on the Bendigo Gold-field, Report No. 1, Nov. 1892; No. 2, July, 1896.

‡ Records Geol. Survey N. S. Wales, 1892, III, Pt. 2, p. 45.

§ Mem. Geol. Survey N.S. Wales, Geol. V, 1894.

This theory of the character and origin of the Broken Hill deposit has met with a varied reception. Amongst those who have adversely criticised it may be mentioned Mr. E. J. Dunn,* who, while giving no reasons in support of his objections, makes the following statement in a short but severe paragraph, which I quote in full:—"In many cases reefs and lodes that bear not the least resemblance to saddle reefs are described as such. The great fissure lode of Broken Hill has been thus confounded through a total misconception of what really constitutes a saddle reef."

In support of Mr. Pittman's theory, Mr. Danvers Powers† states, from his own personal experience, that "at one time the nature of this lode could be seen in the workings of the open cut as if drawn on a giant blackboard, while below ground I have seen perfect subsidiary saddles in the 'centre country.'"

II.—Previous Reference to the Hargraves Saddle Reefs.

Considering the interesting character of these reefs, and the almost perfect manner in which they illustrate this class of deposit, it is surprising that so little notice has been taken of them. The earliest reference to them, as far as I am aware, is that contained in a letter from Mr. Geological Surveyor Jaquet to the Government Geologist, dated 16th August, 1894, in which Mr. Jaquet says:—"I have had my attention called here [Hargraves.—J. A. W.] to what appears to me to be undoubted saddle reefs; in fact, the big reef (Big Nugget Reef), which runs just behind the town, has all the characteristics of these ore deposits. In a small shaft, fifteen feet deep, sunk on the same line of reef, they have struck a reef in which the cap and legs can be clearly seen; moreover, they have put a drill hole down through the centre of the cap, and at a depth of six feet below the bottom of the shaft they have struck another flat-lying body of quartz (a second saddle?). On another claim, about three hundred yards west of the main line of reef, they have met with another saddle reef, where the cap and legs can be seen (a second line of saddles?). The rolling over of the country is not apparent."

Mr. Jaquet again refers to these reefs in his Progress Report for 1894,‡ where he says:—"I found some of them to closely simulate the so-called saddle reefs which occur at Bendigo, Victoria, and I wrote you to this effect. The large reef running behind the town, which yielded when worked many years ago by an English company, large quantities of gold, and from which the famous 'Blackfellow's Nugget' was obtained, would seem to belong to this class of deposit. I am of opinion that shafts should be sunk through the quartz cap of this reef, for the purpose of proving whether other reefs occur beneath it."

* Dept. Mines Vict., Report on the Bendigo Gold-field, 1896, No. 2, p. 23.

† Trans. Austr. Inst. Mining Engineers, 1897, IV, p. 29.

‡ Ann. Rept. Dept. Mines & Agric. N. S. Wales for 1894 [1895], p. 137.

The only other reference to these reefs is that contained in a report by Mr. Slee, Chief Inspector of Mines, dated 24th September, 1894,* where he makes the following remarks:—

"Here [on Warry and Stuart's lease.—J.A.W.] the real saddle reef, similar to those on the Bendigo Gold-field, occur; and I have no doubt that if those interested in mining in the Hargraves district would study this system, which hitherto has been greatly neglected, numbers of persons would receive payable returns for labour and capital expended. Warry and Stuart obtained their crushing from the top of the saddle, about four feet in thickness. The strike of these saddles is about 20° east of south, the legs under lying east and west at an angle of about 20°. About ten feet from the saddle the legs average from eighteen inches to twenty inches in thickness, and, as so far the eastern legs have been worked by former companies, it is of the utmost importance to the district that the western legs should also be tested, as there is no reason whatever why the western legs of these saddle reefs should not yield as large returns of gold as the eastern. A shaft sunk twenty feet south of Warry and Stuart's, which was sunk by the Old English Company some forty years ago, and which has never been worked since, shows within forty feet of the surface, three perfect distinct saddle reefs, which have only been sunk through and left for the present generation to develop; and as these saddle reefs can be traced for a considerable distance north and south from the Big Nugget Hill, and as at least three of these saddle reefs have already been exposed to view, though apparently unnoticed for the last forty years, more of these saddles may be discovered at a greater depth, and an unlimited quantity of payable quartz—which has hitherto been looked upon as worthless—may be the means of profitably employing a large number of persons. Spratt and Milton, south of Warry and Stuart, struck the first saddle reef yesterday in a shaft about thirty feet in depth."

III.—Surface Features.

On the western side of the village of Hargraves is Big Nugget Hill, a slight eminence on which the cap of the Big Nugget Reef outcrops. This was the site, I believe, of the discovery in July, 1851, by an Aboriginal in the employ of Dr. Kerr, of a large mass of gold and quartz, about three hundred pounds in weight, which contained about a hundred-weight of gold. A considerable portion of the cap and east leg of this reef has been removed by an open-cutting along its strike. The true dip of the strata and enclosed reef cannot be made out at the sides of this open cutting, but at its southern end an excellent section (Figure 1) of the cap of this reef is exposed, where it can be seen to lie conformably between bedding planes of slate, and to exhibit distinct evidence of bending over in opposite directions.

* Ann. Rept. Dept. Mines & Agric. N.S.Wales for 1894, [1895] pp 77, 78.

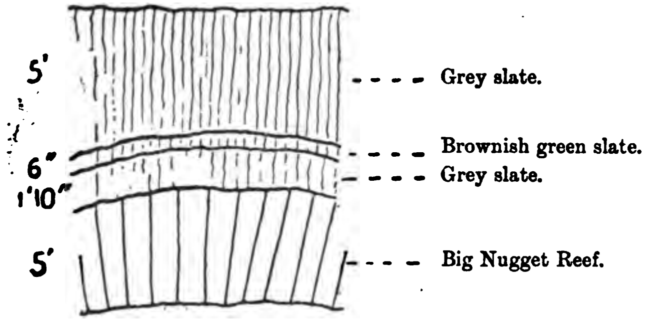

Fig: I

SCALE 0 8 FEET

The cap of the reef consists of white quartz, is five feet thick, and, while at the centre it lies practically horizontal, at the east and west ends of the exposure it dips slightly east and west respectively. Immediately overlying the reef is a band of grey slate one foot ten inches in thickness ; above this is a well-marked band, six inches in thickness, of brownish-green slate, which is capped by five feet of grey slate.

The change in the colour of the slates, not due to surface action alone, marks distinctly the position of the planes of stratification. These would otherwise have been difficult of recognition, for in this "centre country," as it is called, cleavage is highly developed with planes nearly perpendicular.

A little distance to the south of the just-mentioned open-cutting, there is a patch of ground from which the soil and subsoil have been removed and washed for gold. There the folding of the country could be readily made out, and that in spite of the highly developed state of the cleavage planes. The slight inequalities in the surface of the ground furnish natural sections of sufficient extent to enable one, standing ten to twenty yards away, to make out the bending over of the slates in opposite directions from a central line. To the east and west of this line there is clear evidence that the slates dip east and west respectively, and even within a short distance from the axis of the fold the angle of dip is steep.

The whole of the surface evidence, as well as that obtained from the underground workings, tends to show that the anticlinal fold is an exceedingly sharp one ; its cap appears to be not more than ten to fifteen feet wide.

The strike of the fold between the crown of Big Nugget Hill and the most southerly point where it was observed is 10° west of north and east of south. The axis of the fold is not horizontal ; for at one point the cap of the Big Nugget Reef was found to be six feet above the general level of the surface, and at one hundred and twenty feet south of the first point it lies six feet below the surface.

There is thus a "pitch" of one in ten, or of 6° from the horizontal plane. Should this amount of "pitch" be maintained, and the Big Nugget Reef extend as far as the patch of ground mentioned previously, where the soil and subsoil had been removed and washed for gold, its cap would lie at least fifty feet below the surface.

There is evidence at the surface of at least five saddle reefs, in addition to which the under-ground workings on Big Nugget Hill have proved the existence of two others, making seven in all. These will now be described in detail.

IV.—Description of the reefs.

To illustrate the relative positions of the saddle reefs, the ideal section (Figure 2) has been drawn. This is taken at right angles to the axis of the fold, and across the bared patch of ground, where the centre of the anticline was easily located. The reefs have been numbered in descending order, commencing with the highest.

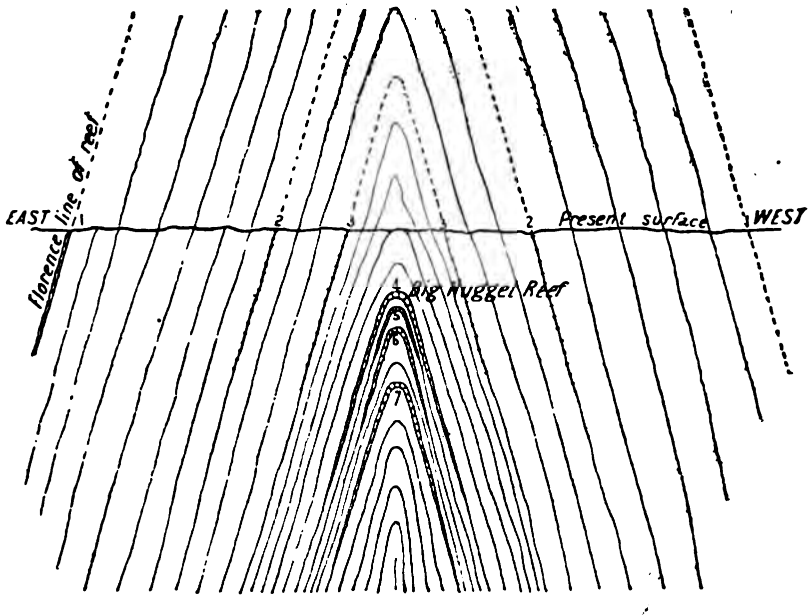

Fig. 2 Scale 0 80 160 feet

Ideal section across the Fold—showing the Saddle Reefs.

No. 1. Ninety yards east of the centre of the fold is the "Florence" line of reef. This reef has been worked for some considerable time. It averages eighteen inches in width, and several parcels of stone from it have yielded from 17 dwt. to 1 oz. of gold per ton. This was not being worked at the time of my visit, because the party of miners previously working it had found it impossible to cope with the water.

It must be confessed that there is no direct evidence to show that this reef represents the denuded east leg of a saddle reef; but there is a strong probability that this is so, for at about a corresponding distance on the opposite or west side of the axis of the fold, a rich shallow alluvial lead has been worked. This exactly

occupies the site where the western leg might be expected to occur, but owing to a thickness of six or more feet of soil the reef itself does not outcrop at the surface. From this site the surface rises gently, going westward, but no gold has been found higher up. As far as I am aware, this site has not been prospected for the reef that might reasonably be expected to exist there, it may be in a pinched condition.

No. 2. Rather more than thirty yards on each side of the axis of the fold are the denuded east and west legs of a saddle reef; the east leg is from three to four inches in width, and from it, I was informed, a party of men obtained in three days as much as £900 worth of gold. The west leg, which is from four to six inches in width, yielded " fair wages " to a party of miners. I think there can be little doubt about these two reefs having originally formed part of a saddle reef, whose cap must have stood originally about 300 feet above the present surface.

No. 3. This is a very small reef, from four to five inches in width, the denuded legs of which lie about thirteen yards on each side of the axis of the fold. The cap of this reef, which has not been worked at all, probably stood originally one hundred feet above the present surface.

Of the foregoing three reefs (Nos. 1, 2, 3) we have only the evidence of their denuded legs, or what appear as such. And here it should be pointed out that although these reefs are narrow where they are now seen, they may have been of considerable thickness in their upper portions, especially at their caps. The denudation of these reefs, and perhaps, of others of smaller dimensions, probably furnished a great part of the alluvial gold found in the neighbourhood.

No. 4. Figure 3 is a section showing the relative positions and extent, as proved by the underground workings, of the saddle reefs Nos. 4, 5, 6, and 7.

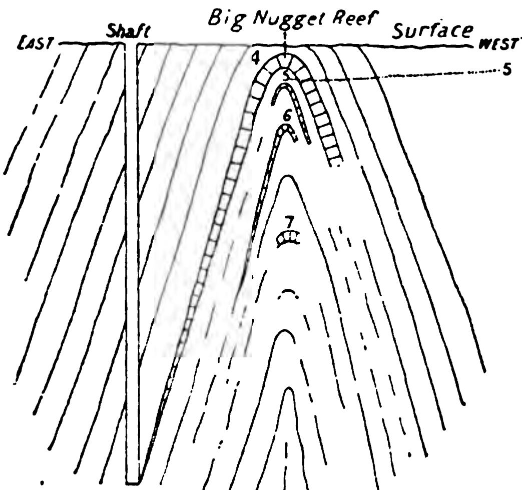

Fig 3

Section of Saddle Reefs—worked by Spratt and party.

Big Nugget Reef (No. 4) is the largest of the Hargraves saddle reefs at present known, being at least five feet thick at the cap. A shaft one hundred and eighty feet in depth and at a distance of sixty feet from the axis of the fold has cut its east leg where it pinches out. In this shaft the country dips at an angle of about seventy-five degrees. The gold contents of this reef near its outcrop are said to be from 4 to 6 dwts. per ton; but a rich shoot of ore has been worked in the eastern leg. This was from forty to fifty feet wide, and pitched at a low angle to S.S.E. The west leg has been worked to a depth of forty feet.

No. 5. Five feet below the Big Nugget Reef is a saddle reef of small dimensions varying from six to eighteen inches in thickness, and consisting of quartz of rather low grade.

No. 6. This saddle reef is situated fifteen feet below No. 5, and varies in width from eighteen inches to two feet. Several small crushings recently taken from it yielded as much as 2 oz. of gold per ton. The eastern leg has been worked for a distance of eighty feet from the surface, where it was found to pinch out. The western leg has been followed down to a depth of thirty-six feet.

No. 7. This is the last reef discovered, its cap being only recently cut in the workings seventy feet from the surface, where it was four feet thick.

A more detailed study than it was possible for me to make would undoubtedly bring to light many interesting facts which have escaped my notice. Such an examination would be of great assistance to the mining community of Hargraves, and might be the means of important discoveries being made. The general character of the work done on these reefs makes it very evident that their mode of occurrence and other characteristics are not generally understood by the local miners.

XXIV.—Notes on the Fauna of the Devonian Boulders occurring at the White Cliffs Opal-fields; by W. S. DUN, Assistant Palæontologist.

[Plates XVII, XVIII.]

IN 1892 Mr. J. B. Jaquet examined the White Cliffs Opal-fields, and drew attention* to boulders occurring in the Upper Cretaceous Beds. A collection of these boulders was made by Messrs. J. B. Jaquet and C. Cullen, Collector to the Survey, and an examination of the fossils contained in them proved

* Ann. Rept. Dept. Mines and Agric. N. S. Wales for 1892 [1893], p. 141.

that they were of Devonian age. Mr. Jaquet makes the following remarks on their occurrence: "Scattered in an erratic manner through the beds of clay and conglomerate, and lying on the surface of the ground, are enormous waterworn boulders of close-grained vitreous-looking sandstone. Some of these boulders are impregnated with oxide of iron, and have, in consequence, a deep brown colour, while others are free from this substance. When broken, in some cases thin veins of opal are seen ramifying through them, and their peculiar vitreous appearance is no doubt due to hydrous silica having been deposited in the interstices of the sandstone. I found in some of these boulders abundant impressions of characteristic Devonian mollusca and other invertebrates. . . . . The question will be asked, "Where did these boulders come from"? About twenty miles westward of the opal-field there is a large elevated area of Palæozoic rocks. These rocks consist of two series, the one consisting of very old slates, having an almost vertical dip, and the other of conglomerates and sandstones, lying uncomfortably on the first series. I think the boulders have been derived from the conglomerates and sandstones."

These fossils comprise Brachiopoda, Pelecypoda, Gasteropoda, Cephalopoda, and Pteropoda, preserved as casts and impressions, nearly always more or less imperfect, so that the determinations have been made in most cases with a great deal of uncertainty, and in nearly all cases it has been almost impossible to make satisfactory comparisons with fossils from other localities.

Some indefinite casts, dendroid and circular in outline are present in the quartzite. The origin of these is uncertain, they may be either Polyzoan or Cœlenterate.

The Brachiopoda are more numerously represented, but with a few notable exceptions they are unsatisfactory. They comprise:—

Orthis (Schizophoria) convexa, *Dun.*
„ „ sp. ind.
Chonetes, sp. ind.
Pentamerus (?)
Rhynchonella pleurodon, *Phillips.*
„ sp. ind.
Spirifera Jaqueti, *Dun.*
„ sp. ind
Athyris sp. ind.
Gen. et sp. ind.

Of these by far the most numerous and best preserved is the *Spirifera Jaqueti.*

The Pelecypoda are also fairly common and as far as their external structure goes are better preserved. They include several genera not previously recorded from Australia. They are:—

Actinopteria australis, *Dun.*
Lyriopecten gracilis, *Dun.*
Pterinea (?)
Leptodesma inflata, *Dun.*
" obesa, *Dun.*
Orthonota.
Grammysia.
Myophoria (?)
Cucullæa (?)

The Gasteropoda are most unsatisfactorily preserved, fragmentary, and as internal casts. They are of no stratigraphical value:—

Murchisonia, sp. ind.
Loxonema, sp. ind.
Euomphalus Culleni, *Dun.*

The widely distributed Pteropod *Tentaculites* occurs in considerable numbers.

Amongst the Cephalopoda are undeterminable species of *Orthoceras* and *Goniatites*

From the genera of Brachiopoda and Pelecypoda present, there, I think, can be no doubt as to the age of the beds that yielded these boulders, and in spite of the unsatisfactory nature of their contents, I am disposed to place them either at the top of the Middle Devonian or as Upper Devonian, but of greater age than the Mount Lambie horizon. On the other hand they offer a more recent facies than that of the Burdekin Beds of Queensland, which have been classed by Messrs. Jack and Etheridge as of Middle Devonian Age, and which are doubtless, very nearly, if not quite, of the same age as the limestones of the Tamworth District and the New South Wales Siluro-Devonian limestones as has been pointed out by Professor David.*

BRACHIOPODA.

Genus.—ORTHIS, *Dalman*, 1828.

(K. Sv. Vet. Akad. Forhandl., 1827, pp. 93, 96. t. 1, 2.)

Subgenus.—Schizophoria, *King*, 1850.

(Mon. Permian Foss. England, p. 106.)

Schizophoria convexa, *n.sp.*

(Pl. XVII, figs. 3, 5.)

Several casts of ventral valves of this form showing the internal structure as well as the outward appearance are in the collection.

The shell is of medium size, transversely elliptical, hinge-line shorter than the width of the shell. Area of valve not seen. In the ventral valve the position of dental plates is well marked and the position of the obovate, elongate area of

* Procs. Linn. Soc. N. S. Wales, 1897, XXI, Pt. 4, p. 569.

muscle attachment is shown in the figures, bounded by a well-marked groove representing in the original a strong ridge. The greater portion represents the attachment area of the divaricator muscles. Occupying a median position between the two divaricators is to be seen, rather indistinctly, a slight raised portion, in the cast, showing the point of attachment of the adductor muscles. The direction of the dental plates is very divergent. But little of the hinge line can be seen. The surface of the valves is ornamented by numerous radiating ridges, primary and secondary, the secondary starting on the lower slope of the convexity. Sometimes even a third series occurs near the margin. There is no trace of any sinus in the valve.

It is with some doubt that this species is placed under *Schizophoria*; what little is known of the position of the dental plates and the general form of the divaricator scars approximating to conditions obtaining in that genus.

In 1850, King proposed* that Orthids of the type of *O. resupinata* should be included in a new genus, or subgenus *Schizophoria*, possessing typically "an open fissure, often rounded umbones, large punctures, and the valves in general arcuately triated in the cardinal lateral regions." Between *Orthis resupinata* Martin, so common in Carboniferous Beds, and *O. striatula*, Schlotheim, there is little difference, and Davidson in his Devonian Monograph† says, after a discussion of the synonymy of the species, that "it is, however, very possible and probable, that *O. striatula* is a smaller variety of *O. resupinata*." One thing certain is that our species is not a typical *striatula*‡ or *resupinata* on account of the relatively greater length of the hinge line, and the absence of a sinus in the ventral valve.

The subgenus has a range, in America from the Clinton, through the Lower Helderberg, Corniferous, and Hamilton up to the Coal Measures.

Schizophoria, sp. ind.

(Pl. XVII, fig. 1.)

In the collection from White Cliffs are several specimens of single valves similar to that figured in Pl. XVII, Fig. 1, that are taken to be the impressions of pedicle valves of an *Orthis* and belonging to the sub-genus *Schizophoria*. The cavities left by the dental lamellæ are shown. The outline, as preserved, is of the same general type as that of *Orthis* (*Schizophoria*) *Swallovi*, Hall,§ from the Burlington Limestone, there being the same rounded cardinal angles, fine and closely striated surface and indications of concentric growth ridges; it is also of the same general size. The species bears no resemblance to the Devonian forms figured by Hall.‖

* Permian. Foss. England, p. 106.
† Brit. Foss. Brach., II, p. 90; see also Hall's description of the genus, Pal. N. York, 1892, VIII, Pt. 1, pp. 211-213.
‡ Davidson, *Op. cit.*, pp. 87-90, pt. XVII, figs. 4-7.
§ Pal. N. York, 1892, VIII, Pt. 1, VI, figs. 23, 24; Pal. Iowa, 1858, I, Pt. 2, p. 597, XII, fig. 5.
‖ *Op. cit.*, pls. VI, VI A.

Genus.—LEPTÆNA, *Dalman*, 1828.

(K. Sv. Vet. Akad. Handl., 1827, pp. 94–96, 106, 107.)

Leptæna rhomboidalis, *Wilckens* (?)

Davidson, Brit. Foss. Brach., III, p. 281–283 (*for synonymy*).

(Pl. XVII, fig. 11.)

I have little hesitation in referring to this cosmopolitan species the specimen figured on Pl. XVII, Fig. 11. It represents an imperfect brachial valve, distorted, showing the cardinal process and the septum, and also the characteristic concentric wrinkles.

A detailed summary of the reasons for transferring this well-known species from *Strophomena*, under which it has been placed by Davidson and many others, will be found in Professor Hall's "Introduction to the Study of the Palæozoic Brachiopoda."*

The species is common in Australian Silurian and Siluro-Devonian rocks. The variety *analoga*, Phillips, is common in the Carboniferous.

Genus.—CHONETES, *Fischer de Waldheim*, 1837.

(Oryct. Gouv. Moscou, Pt. 2, p. 134.)

Chonetes, *sp. ind.*

(Pl. XVII, fig. 15.)

An impression of the pedicle valve of an undeterminable species of *Chonetes* is represented in the collection. This is one of the finely-striated species, the hinge line is very oblong, and, as preserved, the valve is only moderately convex. On one side is seen the indistinct trace of the ridge bounding the divaricator muscle scar. Had this mark been more intense, it would have pointed to the specimen being one of the Strophomenidæ, and have represented the position of the dental plates. However, the general appearance of the impression points rather to its being a *Chonetes*, allied to *C. hardrensis*, Phillips† from the Devonian of England. It also agrees in general size and number of striæ with Davidson's figure‡ in his Devonian Monograph, one of Phillips' original specimens from the Upper Devonian.

Mr. R. Etheridge has described a *Chonetes* from the Carboniferous of Queensland as *C. cracowensis*, which in general form is very similar to the White Cliffs specimen. *C. cracowensis*, Eth. is separated from *C. Laguessiana* of De Koninck

* 1892, pp. 279–280.
† Pal. Foss. Dev. Cornwall, 1841, t. 58, f. 104.
‡ Brit. Foss. Brach. III, t. 19, f. 7.

(which the latter Author considers to be Davidson's Carboniferous. *C. hardrensis*).* Mr. Etheridge separates *C. cracowensis*† on the strength of the flatter cardinal angles and more spinose nature. Mr. R. Etheridge, jun., concurs in this opinion, still keeping the species separate.‡

Genus.—PENTAMERUS, *J. Sowerby*, 1813.

(Min. Conch., I, p. 76.)

Pentamerus (?).

(Pl. XVII, fig. 9.)

I cannot see any other genus except *Pentamerus* to which this small specimen can be referred, at any rate as far as our present knowledge goes. The shell appears to have been strongly convex, with a curved hinge-line, prominent beak, and with two very large septal plates, slightly diverging, in the brachial valve, extending for considerably more than one-half the length of the shell. These septal plates are widely separated to the extent of nearly a third of the width of the shell. I can find no figure of a pentameroid showing a similar disposition of these plates, still there appears to be no other genus under which it will come. There is little doubt that it is a new species, still the material is too limited to enable a satisfactory diagnosis to be drawn up. The main character of value for separation is the distance apart of the septal plates.

Genus.—RHYNCHONELLA, *Fischer*, 1809.

(Nat. Foss. Gouv. Moscou, p. 35.)

Rhynchonella pleurodon, *Phillips.*

(Pl. XVII, fig. 16.)

Terebratula pleurodon, Phillips, Geol. Yorkshire, 1836, II, p. 222, pl. XII, figs. 25–30.

Rhynchonella ,, Davidson, Brit. Foss. Brach., II, pp. 101, 246, pl. XXIII, f. 1–15, 16–22 (*for Synonymy*). *Op. cit.*, III, p. 62, pl. XII, f. 12–13.

,, ,, De Koninck, Foss. Pal. N. Galles du Sud, 1876, Pt. 2, p. 95; *id.*; *ibid.*, 1877, Pt. 3, p. 219, t. 9, f. 4.

,, ,, Etheridge, R., junr., Cat. Austr. Foss., 1878, p. 54.

,, ,, Etheridge, R., junr., Geol. and Pal. Queensland, 1892, p. 244, pl. II, f. 23.

A few impressions indicate the presence of this common and widespread Brachiopod. The specimen figured represents part of the pedicle valve, showing the well-marked sinus containing four strong ribs.

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* *Op. cit.*, II, p. 126, t. 47, f. 12–25.
† Quart. Journ. Geol. Soc., 1872, XXVIII, p. 336, t. 18, f. 2.
‡ Geol. and Pal. Q'land, 1892, p. 262, t. 13., f. 9.

This species has a world-wide distribution in rocks of both Devonian and Carboniferous age. Only a few of the more important references are given in the synonymy.

In Australia it is particularly abundant in the Upper Devonian Beds of Mount Lambie and the surrounding district, Sunny Corner, Henbury Hill (near Rylstone), Sugar-loaf Mountain (Clyde), Eden, Sofala. It has also been collected from Carboniferous beds in New South Wales and Queensland.

Rhynchonella, *sp. ind.*

(Pl. XVII, fig. 4.)

This specimen is taken to represent part of a very broad wedge-shaped *Rhynchonella*, after the type of *R. trilaterata*, De Koninck, from the Carboniferous of Belgium and England, as figured by Davidson,* than which it is much larger and relatively wide. It also somewhat resembles *R. cuneata*, Dalman,† a widely-distributed Silurian species; but from this also it is separated by the width. The surface is strongly ribbed; in the wide sinus there appear to be at least four ribs. The last-mentioned species is taken as the type of Prof. James Hall's *Rhynchotreta*.‡

Genus.—SPIRIFERA, *Sowerby*, 1815.

(Mineral Conchology, II, p. 42.

Spirifera Jaqueti, *sp. nov.*

(Pl. XVII, figs. 2, 12, 13, 14, 17.)

Shell small, hinge-line the width of the shell, cardinal angles rounded, valves equally convex. Dorsal valve with well-marked mesial fold, flattening towards the margin; on either side of the fold are four or five well-marked radiating ridges, with a fainter one near the cardinal angle. Ventral valve has a deep sinus, with generally five well-marked ribs on either side, and sometimes there is a faintly-marked sixth rib at the margin near the cardinal angle. The umbo is well marked and slightly overhangs the area, which is not very high; traces of the triangular dethyrium are to be seen in one specimen. From several of the casts it is evident that the dental plates of the pedicle valve are short and thick, leaving well-marked hollows. No other points of the internal structure can be made out. Average dimensions, 15mm. broad, 8 long.

This *Spirifera* may, I think, be considered to be specifically and generically distinct from such forms as *Spiriferina cristata* of the European Devonian. At first sight the general appearance is so similar to that of specimens of *Spiriferina cristata*, figured by Davidson from the Devonian,§ that were it not for the want of

* Brit. Foss. Brach., II, p. 109, t. XXIV, figs. 23–26.
† *Op. cit.*, III, p. 164, t. 21, figs. 7–11.
‡ Ann. Rept. N.Y. State Mus. Nat. Hist., 1879, XXVIII, p. 166; Pal. N. York, 1892, VIII Pt. II. p. 185.
§ Dev. Brachiopoda, 1863, pp. 46–48, t. VI, figs. 11–17.

shell structure showing punctæ and a median septum, it would be, perhaps, safer to class them under a variety of that variable and wide-spread genus. At the same time, Professor James Hall and Clarke's* remarks on this matter must not be overlooked. They say, speaking of the evolution of *Spiriferina* from "the lamellose-septate Spirifers, whose inception dates from the faunas of the Upper Silurian. Though none of these Silurian and Devonian species, in the American faunas, developed a punctate shell structure, they usually bear the lamellose, often radially striated exterior, prevailing among the Spiriferinas of the Carboniferous. Mr. Davidson has described two of these lamellose species from the Devonian, which have a strongly punctated shell, *Spiriferina cristata*, Schlotheim, var. *octoplicata* and *S. insculpta*, in which it has not been conclusively shown that the median septum exists, though this is a legitimate inference."†

From this quotation, and the figures, it will be seen that while there is no doubt that this species is without doubt a *Spirifera* in the broad sense, still there is little probability of it belonging to *Spiriferina*.

Spirifera, *sp. ind.*

(Pl. XVII, fig. 10.)

This specimen is unfortunately but ill-preserved, but gives us evidence of another type of *Spirifera* in this fauna. The hinge line was long, cardinal angles rounded, beak of the brachial valve not very prominent, crural processes not very large, long, but not very prominent, median septum present; median fold well-developed, bearing about ten small thin ribs. Surface ornamented with numerous primary and secondary ribs which are not prominent. There is also evidence of four concentric growth lines.

The specimen is too imperfect to enable satisfactory comparisons to be made. The most salient point in its structure appears to be the great development of the median septum in the dorsal, a structure that is generally absent in *Spirifera*.

Genus.—ATHYRIS, *McCoy*, 1844.

(Synop. Carb. Foss. Ireland, p. 123.)

Athyris, *sp. ind.*

(Pl. XVII, fig. 6.)

This appears to me to be referable to *Athyris*. The specimen represents the cast of a brachial valve, showing the impression of the well-developed median septum or ridge. The shell was a little broader than long, the cardinal angles well rounded, the beak not prominent, and the valve ornamented with well-developed concentric growth ridges. The fold is not very strongly marked.

* Dev. Brachiopoda, 1863, pp. 46–48, t. 6, figs. 11–17.
† Pal. N. York, 1894, VIII, Pt. 2, pp. 53–54.

To *A. concentrica*, Von Buch, as figured by Davidson,* there is some resemblance, and though it does not correspond with any of the forms figured by that author, there is a probability of our specimen being a variety of that Devonian species.

Brachiopoda, *ind.*

I have been much puzzled with the original of Pl. XVII, Fig. 7. It is beyond doubt a Brachiopod, and one of the curved hinge-line forms. The attachment scars of the two large divaricator muscles are very large and elongate-ovate, separating the greater portion of them is a ridge continued from the lower extremity of the smaller adductor area. There is no well-marked ridge marking the boundary of the divaricator muscles, they being attached to a gradually deepening space. There were evidently two diverging dental plates. The valve at the apical portion must have been very thick at the sides, attaining a thickness of a fifth of an inch. The remainder of the shell was rather thin, and ornamented with a large number of radiating costæ. The sinus was small, the area high.

There is a possibility of this being one of the Atrypidæ, and perhaps even *Atrypa*, with which it has a great deal in common in the arrangement of the muscle scars. On the other hand, there is a great difference in the thickness of the sides and the greater development of the beak in the White Cliffs specimen, and also in the presence of the ridge between the divaricator muscle scars—an item that is wanting in *Atrypa*. There is also resemblance to the *Rhynchonellidæ*, with which it agrees in the possession of this ridge, but differs from in the relative position of the muscle scars.

PELECYPODA.

Genus.—ACTINOPTERIA, *J. Hall*, 1883.

(Pal. N. York, V, Pt. 1, 1884, p. 12; Plates and Explanations, 1883, pl. XXV, fig. 1.)

Actinopteria australis, *sp. nov.*

(Pl. XVIII, figs. 14, 15.)

Left valve of moderate size, slightly oblique, convex, longer than broad. Umbo apparently not very marked (it has been broken off in the specimens) and anterior, shell gradually convex from the umbo to the border. Hinge-line straight, about one-sixth less than the length of the shell, extending probably in perfect specimens a little beyond the posterior margin. The beak is imperfect, but judging by what remains was most likely acute and directed forward and almost terminal, anterior. The anterior ear is also wanting, but must have been small; while the posterior ear or wing is large, triangular, excavate, with a strongly concave margin and an acute extremity. The wing is almost flat, and separated from the convex umbonal portion by a much more gradual convexity. The shell was thin and ornamented

* Brit. Foss. Brach., III, pl. III, figs. 11-15.

with both concentric growth lines, the general direction of which is shown in Pl. XVIII, Fig. 15, while in Fig. 14 are shown the radiating ribs. These are fairly close, and appear to be to a slight extent alternately larger and smaller; the larger ones —the primary—extend to the umbonal region, but owing to the indistinct mode of preservation it is impossible to trace the secondary ribs. No trace of ribs can be seen on the ears as preserved.

Length	42	millimetres.
Width	32	"
Hinge-line	37	"
Depth of valve	6	"

There can be no doubt that this shell is one of the Aviculoid shells, and as far as one can judge from its appearance, in the absence of internal structure, and its association, may be classed under Hall's genus, which was formed for *Pterinea*-like shells without "a broad striated ligamental area and strong cardinal and lateral teeth." It is also like, in outline, some species of the same Author's *Leiopteria* which differs from *Actinopteria* in outward characters, mainly in the absence of radiating ribs. Compare for instance *Leiopteria Conradi*, Hall,* which is a little more oblique and relatively transverse than our species. It is much less oblique and relative transverse than the American Devonian species figured by Professor Hall, and these points, together with the greater extension of the hinge-portion of the wing, will easily separate it from *A. muricata, Doris, subdecussata, decussata, Boydii, perobliqua.* To Mr. Whidborne's *A placida*† there is also some resemblance, but the Australian form is less transverse and oblique, and the anterior ear appears to have been much less developed.

Genus.—LYRIOPECTEN, *Hall*, 1883.

(Pal. N. York, 1884, V, Pt. 1, p. 12; M.S., *op. cit.*, 1877, V, *Fide* Miller, N. Am. Pal.)

Lyriopecten gracilis, *sp. nov.*

(Pl. XVIII, fig. 8.)

Left valve of moderate size, regular, gently convex, wider than long, hinge-line much shorter than the width of the shell, anterior ear small, almost rectangular, with slightly concave margin, clearly marked off from the anterior umbonal slope, not ornamented with ridges only with growth lines. Posterior expansion larger, not quite so sharply marked off from the posterior umbonal slope as imperfectly preserved, but not so concave in its posterior margin, umbo not prominent. Shell on the whole shallow, surface ornamented with numerous fine radiating ridges, of

* Pal. N. York, 1884, V. 1, Pt. 1, t. 20, f. 4.

† Dev. Fauna S. England, 1892, II, Pt. 2, p. 67, t. 7, f. 9.

alternating thickness, which appear to be primary and secondary, the last mentioned arising at about a third the distance from the umbo and running to the margin, increasing slightly in size; no traces of concentric growth lines are preserved.

Length	23	mm.
Width	27	„
Hinge-line	13	„
Anterior ear, length	6·5	„

Professor James Hall instituted the genus *Lyriopecten* for forms generally similar to *Aviculopecten*, but differing from it "in the short hinge-line and very small anterior ears. Test usually ornamented with strong rays." This shell is unfortunately imperfect, but enough remains to enable comparisons to be made with already described forms. Our species differs from the American Devonian forms in its smaller size, less prominence of ribbing, and lesser degree of obliquity.

Genus.—PTERINEA, *Goldfuss*, 1826.

Pterinea ?

(P.P. XVIII, fig. 4)

It is possible that this may represent part of a small species of *Pterinea*, with very prominent costæ, more cannot be said.

Genus—LEPTODESMA, *Hall*, 1883.

(Pal. N. York, V, Pt. 1, Plates and Explanations, pl. XVII, fig. 12; *op. cit.* [1884], pp. xii, 175.)

Leptodesma inflatum, *sp. nov.*

(Pl. XVIII, fig. 3, and ? fig. 6.)

Shell small, very deep, rhomboidal, oblique, umbonal region high, anterior and posterior sides almost parallel. Hinge-line straight, but little greater than the width of the shell. Left valve only known, strongly convex. Beak small, directed forwards, at about anterior third of the hinge-line. Anterior umbonal slope steep, separated from the anterior expansion by a gradual concavity. Anterior expansion small, blunt (this is too strongly accentuated in Fig. 3), being of moderate size, extending to the posterior extremity, margin straight; posterior umbonal slope less marked than in the case of the anterior, gradually concave. Surface ornamented with a few indistinct concentric growth lines.

Length	21	mm.
Width...	15	„
Length of hinge-line...	15	„
Depth...	9·5	„

L. inflatum appears to be easily distinguished from most of its congeners by its more elongate oblique form and much greater depth of shell and non-extension to the slightest degree of the posterior extremity of the hinge-line. There is a slight general resemblance to *L. Orodes*, Hall* but it differs from the American form in the lesser obliquity and much greater depth. In America the genus is very common in the Chemung Group.

Pl. XVIII. fig. 6 represents, I think, a younger form of the same species.

Leptodesma obesum, *sp. nov.*

This species may be distinguished from *L. inflatum* by the much greater development of the umbonal region, greater inflation and prolongation of the beak, general lesser obliquity and tendency towards squareness of the shell. The anterior ear is smaller and more inflated. The posterior wing is small, not so flattened as in the preceding species, and the posterior margin not marked off in outline from the general convexity of the posterior margin.

Length	... ...	18 mm.
Width	... ...	16 „
Hinge-line	... ...	16·5 „
Depth	... ...	7 „

Genus—ORTHONOTA, *Conrad*, 1841.

(Ann. Rept. N. York Geol. Survey, p. 51.)

Orthonota, *sp.*

(Pl. XVIII, fig. 2.)

This small species, though unfortunately too imperfect to enable one to say so definitely, appears to be different from any hitherto described *Orthonota*, using the term in its broadest sense. It is remarkable for the very marked ridge bounding the posterior umbonal slope. This ridge is very acute and almost a sigmoidal trend. There appears to be no ridging on the posterior umbonal slope. There is a slight constriction of the basal margin formed by a not prominent cincture.

Length	... ...	29 mm.
Height	... ...	6 „

Genus—GRAMMYSIA, *De Verneuil*, 1847.

(Bull. Soc. Geol. France, IV (2), p. 696.)

Grammysia, *sp. ind.*

(Pl. XVIII, fig. 1.)

It is possible that the imperfect specimen represented by this figure may be one of the very slender *Grammysia*. There are evidences of a well-marked plain cincture, forming a very marked constriction in the basal margin.

* *Op. cit.*, 1884, p. 206, t. 25 f. 6, 9, t. 90, f. 8.

Pelecypoda, *gen. ind.*

Of these two fossils shown in Plate XVIII, figs. 5 and 7, nothing can be said. There is absolutely no trace of the hinge structure preserved. Figure 7 may be a *Myophoria*, and perhaps fig. 5 may be considered for the time being as one of the very large group of Palæozoic bivalves classed under *Cucullæa*, which has been used as a resting place for numerous ill-preserved arcoid shells of uncertain affinities.

GASTEROPODA.

Genus—MURCHISONIA, *D'Archiac and De Verneuil*, 1841.

(Bull. Soc. Geol. France, XII, p. 154.)

Murchisonia, *sp. ind.*

(Pl. XVIII, fig. 11.)

The impression of a portion of a turreted gasteropod, showing indistinct traces of the band, is also found at this locality. Parts of five whorls, having a height, as preserved, of nearly 1¼ inch, are shown; the whorls are regularly convex, the band does not appear to have been prominent, the sutures are well marked, and the angle of inclination of the sides is about 14°.

Genus—LOXONEMA, *Phillips*, 1841.

(Pal. Foss. Devon., p. 98.)

Loxonema, *sp. ind.*

There is also in the collection a cast of a small *Loxonema* after the type of *L. trochleatum*, Munster,* on a large scale; its whorls have a height of—body whorl, of 6·5 mm.; second last, 4 mm.; and last four whorls, a quarter of an inch. These whorls are squarish, not very convex, suture slightly marked, and the angle of inclination of the sides about 10.° De Koninck records a *Loxonema* from the Yass District that he identifies with the European species† *L. antiquum* also of Münster, and as a synonym of it gives *L. subulata*, Roemer,‡ and also of Sandberger.§ Mr. Whidborne‖ refers to these two author's species as being synonymous with *L. trochleatum* Münster. From what little is preserved our specimen agrees very closely with that Author's figures in all except size and slight difference in inclination of the sides. The White Cliffs specimen evidently decreases in width more rapidly than *trochleatum*; in De Koninck's figure of *antiquum*, the apical angle is said to be 5°; in this form it appears to be nearer 10°. The whorls are much more perpendicular to the axis than in De Koninck's Fig. 10, approaching more to that

* Beitrage zur Petrefactenkunde, 1840, III, p. 88, t. 15, fig. 18.
† Pal. Foss. N. Galles du Sud, 1878, p. 125, t. 4, f. 10.
‡ Versteinerungen Harzgebirges, 1843, p. 31, t. 8, f. 12, 12A.
§ Versteinerungen Rhein. Sch. systems Nassau, 1850, p. 229, t. 26, f. 10.
‖ Mon. Dev. Fauna S. England, 1886, III, Pt. 1, p. 41, t. 5, f. 4-5A.

of his Fig. 10A, and again less square than in Mr. Whidborne's figures. There appears to be no trace of the "flat rim under the suture" mentioned by that Author as occurring in the English form. The surface appears to have been smooth.

Genus—EUOMPHALUS, *J. Sowerby*, 1814.

(Min. Conch., I, p. 97.)

Euomphalus Culleni, *sp. nov.*

(Pl. XVIII, figs. 12, 13.)

Shell of moderate size, conical, depressed, three whorls, but little elevated beyond the body whorl; decrease of whorls in size gradual, upper angle convex, evidences of a faint shoulder near the suture, which was not deep; lower angle of body whorl more convex than the upper.

Height	11 mm.
„ of body whorl	8 „
Diameter...	17 „

The tapering of the shell is rapid and regular; the basal portion of the shell appears to have been strongly concave.

I know no species with which I can compare this, except *E. vermis*, Whidborne,* from the Devonian of the South of England, than which it is much larger. In *E. vermis*, which is very minute, the whorls have a squarer appearance, and the body whorl is relatively larger than in our species. Compare also *Straparollus mopsus*, Hall, from the Niagara group of North America.†

Genus.—TENTACULITES, *Schlotheim.*

(Petrefactenkunde, 1820, p. 377.)

Tentaculites *cf.* bellulus, *Hall.*

(Pl. XVIII, figs. 9, 10.)

Numerous fragments of *Tentaculites* occur in the White Cliffs quartzite. The form is long, slender, gradually tapering. Annulations thick, obtuse, less in width than the spaces separating them, about three to a millimetre, closer together towards the apex, where they are much less marked. There appears to be little or no trace of transverse striation between the annulations. The enlargement figured in Pl. XVIII, Fig. 9, may possibly represent another species; in this the annulations are arranged in sets of three, with a wider space between them.

* Dev. Fauna S. of England, 1896, III, Pt. 1, p. 52, t. 5, f. 4–4A.
† Rept. State Cab. Nat. Hist. N. York State, 1867, XX, p. 342, t. 15, f. 21, 22.

None of the shell is preserved, so that its affinities are doubtful. It appears to me to be close to *T. bellulus*, Hall,* from the Hamilton Series. None of the forms figured by Barrande† resemble it very closely. There is also some general resemblance to *T. ornatus*, Sowerby.

Mr. R. Etheridge, junr., has described‡ a *Tentaculites* from the limestone of Wellington, New South Wales, for which he suggests the name *T. Liversidgei*, should further investigation prove it to be new. This appears to be larger and the annulations more acute than in the White Cliffs species.

Genus.—ORTHOCERAS, *Breynius*, 1782.

(Dissert de Polythal, pp. 12, 25.)

Orthoceras, *sp.*

(Pl. XVII, fig. 8.)

Two specimens, very imperfect, of an indeterminable *Orthoceras* occur in the collection. One of these, figured in Pl. XVII, Fig. 8, shows the traces of four septa. The width of the cast of the shell is 21 millimetres, the distance between the septa about 5 mm., and the angle of inclination of the sides about $6° 30'$; shell evidently very long, straight, septa slightly inclined.

A form, either the same or else closely allied to this, occurs in several of the Palæozoic sandstones of the Western District. In its imperfect state it is impossible to institute comparison with any of the hitherto described species. There may be some relation to *O. procerus*, Hall, from the Devonian of the United States.§

Genus.—GONIATITES, *De Haan*, 1825.

(Mon. Ammon et Goniatites, p. 39.)

Goniatites, *sp. ind.*

(Pl. XVIII, fig. 16.)

What is taken to be the dorsal portion of a *Goniatites* is represented in Pl. XVIII, Fig. 16. It cannot be freed from the matrix. The contour, viewed from the dorsal side, appears to have been very triangular, and the width, judging from the specimen as preserved, a little greater than the length, nearly a quarter of an inch. No trace of the sutures is preserved, so that it is impossible to say under which of the sections of *Goniatites* it should rest.

* Pal. N. York, 1879, V, Pt. 2, p. 169, t. 31, f. 15–18, t. 31 A, f. 48–51.
† Syst. Sil. Boheme, III.
‡ Journ. R. Soc. N. S. Wales, 1880 [1881], XIV, p. 253, pl. , figs. 10, 10a.
§ Pal. N. York, 1879, V, Pt. 2, p. 249, t. 35, f. 15; t. 79, fig. 5.

XXV.—Palæontologia Novæ Cambriæ Meridionalis.—Occasional Descriptions of New South Wales Fossils, No. 3: by R. ETHERIDGE, Junr., Curator of the Australian Museum, Sydney.

(*Continued from Vol.* V, *Pt.* 1, *p.* 18.)

[Plate XIX.]

1.—*Generic Position of* Rhynchonella inversa, *De Koninck.*

Pl. XIX, Figs. 1–13.

IN his work on the Palæozoic Fossils of New South Wales, the late Prof. L. G. de Koninck described a Permo-Carboniferous Brachiopod under the above name.*

He may possibly have been led to place his species in this genus from its general resemblance to the *Rhynchonella angulata*, Linn., as he instituted a comparison between the two forms. The specific description of *R. inversa* was very clearly and correctly given; but it seems to me that De Koninck's conception of its generic affinity, and his reading of the relative positions of the fold and sinus,† was erroneous. The chief point of interest about this species lay in the transfer of the dorsal fold to the ventral valve, and of the ventral sulcus to the dorsal valve. To my mind there is nothing abnormal in the structure of these portions of *R. inversa*, the "sinus médian assez profond" of the dorsal valve being simply a sinus in the centre of the fold, which is represented by "un pli" on each side; whilst the "pli médian" of the ventral valve is nothing more than a fold in the sinus of the latter, the "deux autres plis oblique" being the lateral boundaries of the sinus proper. This condition, varying only in degree, is to be seen in many Brachiopoda—for instance, the Cretaceous *Terebratula biplicata*, Brocchi; the Cornbrash, *T. Bentleyi*, Morris; some forms of the Carboniferous *Dielasma hastata*, Sby.; the Lower Silurian *Orthis insularis*, Eichwald, and others. *Rhynchonella inversa* is, in truth, merely an abnormal *Dielasma*.

Some internal casts of the dorsal valve exhibit the small but well-developed lozenge-shaped muscular platform characteristic of *Dielasma*, and it is to this genus that I propose to transfer De Koninck's species. It is not visible in all specimens of the dorsal valve, but I have been fortunate enough to obtain a satisfactory wax relief (Pl. XIX, Fig. 11), taken from a good internal cast (Pl. XIX, Fig. 10), that shows the platform excellently. In all, the cavities left by the dental plates of the ventral valve, and the edges of the dental sockets in the dorsal valve, are visible—portions that seem to have been well developed in *D. inversa*. In some examples the short dorsal septum is seen (Pl. XIX, Fig. 5), and in a rather abnormal

* Foss. Pal. Nouv.-Galles du Sud, Pt. 3, 1877, p. 220, t. 11, f. 8.
† *Loc. cit.*, p. 221.

variety (Pl. XIX, Fig. 8) the fold of the ventral valve is grooved in the cast, representing a ridge in the shell. It has, however, been too forcibly represented in the drawing.

D. inversa exhibits some amount of variation in form. De Koninck figured an example broad across the centre of the valves, attenuating rapidly towards the front, and with a high and rather narrow ventral umbo. In Pl. XIX, Figs. 12 and 13 a somewhat similar individual is represented; but in all the other illustrations now given the shell is proportionately shorter from umbo to front and deeper through the valves, whilst another variety (Pl. XIX, Figs. 7–9) is essentially broad across the latter. There is also variation in the sigmoidal curvature of the lateral margins. In De Koninck's Fig. 11A the latter are flexuous; in our Pl. XIX, Fig. 1, they are more strictly sigmoidal; in Pl. XIX, Fig. 4, simply rounded; whilst in Pl. XIX, Fig. 9, although again rounded, the margins of the dorsal valve project backwards, impinging greatly on the capacity of the ventral valve, and with an almost vertical middle line. In fact, this deepening of the sides of the dorsal valve is very much like what takes place in *D. cymbæformis*, Morris;* but in this species the fold and sinus are normal in character.

Locality and Hor.—Near Pont's House, between Regent Street Crossing and Maitland Colliery (Pl. XIX, Figs. 4–10, Maitland (*J. Waterhouse, M.A.*); Quarry, about a quarter of a mile north-west of the Waterworks (Pl. XIX, Figs. 12 and 13), West Maitland (*J. Waterhouse, M.A.*).—Upper Marine Series, Permo-Carboniferous. Harper's Hill (Pl. XIX, Figs. 1–3), near West Maitland (*J. Waterhouse, M.A.*)—Lower Marine Series, Permo-Carboniferous.

2.—Platyschisma oculus, *J. de C. Sowerby*.

(Pl. XIX, Figs. 14–17.)

This characteristic Gasteropod of our Lower Marine Series passes through much variation in the height of its spire. The original figure by J. de Carle Sowerby,† as *Trochus oculus* represented an individual with a depressed spire, and with the first and second whorls hardly raised above the third in a side view or elevation. As *Platyschisma oculus*, Morris‡ figured a high shell, with four whorls visible in a similar position; whilst Dana§ in his splendid work detailing the Geological results of the Wilkes' United States Exploring Expedition, gives an illustration of one, although apparently less in height, still with the four whorls in evidence. Plews,‖ notwithstanding a rough drawing, illustrates an extreme form in the

* Strzelecki's Phys. Descrip. N. S. Wales, &c., 1845, t. 18, f. 1.
† Mitchell's Three Exped. Int. E. Australia, 1838, I, p. 15, t. 2, f. 3 and 4.
‡ Strzelecki's Phys. Descrip. N. S. Wales, &c., 1845, p. 286, t. 18, f. 1.
§ Wilkes U.S. Explor. Exped., X, Geology, 1849, p. 707, t. 10, f. 1.
‖ Mining Inst. Journ., 1858 VI, Pt. 3, t. 4.

height of the spire; and lastly De Koninck* in referring the species to *Euomphalus*, whilst figuring the whole four whorls visible in a side view, gives a decidedly less elevated shell than Plews.

In Pl. XIX, Figs. 14–17, is a very depressed variety that might, under ordinary circumstances, and with justification, be regarded as specifically distinct. It will be observed that instead of four whorls only two are visible in a side view (Pl. XIX, Figs. 14 and 15), the first and second are sunk or depressed below the sutural line of the third, as is so frequently seen in Euomphaloid shells. Between this condition and the high-spired, or what may be called the typical form, every gradation exists.

The present specimen also displays the sculpture in a fine state of preservation, more so than is usually the case. The regularity of the fine, sharp, oblique threads is beautifully retained, as well as the backward flexure over the obtusely angular periphery of the body whorl (Pl. XIX, Fig. 17), but without the faintest trace of a band, or a sinus on the outer lip, in accordance with the generic position of the species. At the same time, on portions of the surface are remarkably fine spiral, and occasionally wavy wrinkles, more particularly on the upper and lower aspects of the body whorl, that under the lens are seen to break it up into a series of minute parallelograms. Of the two, this is even more apparent on the lower surface (Pl. XIX, Fig. 15).

Locality and Hor. Harper's Hill, near West Maitland (*T. Waterhouse, M.A.*)—Lower Marine Series, Permo-Carboniferous.

3.—Actinoconchus planosulcatus, *Phillips, sp.*

(Pl. XIX, Fig. 18.)

On two former occasions I figured spine-bearing examples of an *Athyris* from the Permo-Carboniferous of Queensland. Both were referred to *Athyris Roysii*, Lev.,† or as it must now be called *Cliothyris Roysii*, Lev., sp. Through the light thrown on the matter by the acquisition of the present specimen (Pl. XIX, Fig. 18), I am induced to believe that I was wrong in referring the second of these, that from the Rockhampton District, to *Cliothyris Roysii*. I now consider it to be an example of *Actinoconchus planosulcatus*, and identical with that at present under consideration from New South Wales.

In *A. planosulcatus* the growth lamellæ of the valves are extended as successive semicircular frills, each frill flat and longitudinally striate. A portion of these is seen in the figure of the specimen just referred to, and two portions of another in Pl. XIX, Fig. 18. In neither case are the plates subdivided into separate spines, as in *Cliothyris Roysii*, but are continuous and grooved radiately. The late

* Foss. Pal. Nouv.-Galles du Sud., Pt. 3, 1877, p. 330, t. 23, f. 18 *a—c*.
† Geol. and Pal. Queensland, 1892, p. 248; Proc. Linn. Soc. N. S. Wales, 1895, IX (2), p 529, t. 39, f. 4.

Dr. Thomas Davidson always spoke of these grooves as striæ, but the acquisition of more perfect examples enabled Messrs. Hall and Clarke* to show that the lamellæ surrounding the shell of *Actinoconchus planosulcatus* consisted of "fine tubular spines connected by, or embedded in a tenuous calcareous plate," or plates. This is entirely borne out by the structure of the present specimen, for on placing it under a moderately high magnifying power it is at once apparent that each of the radii is hollow, and filled now with clear calcite.

Locality and Hor.—Dungog Road, nineteen miles from West Maitland, Parish of Barford, County of Durham (*J Waterhouse, M. A.*)—Carboniferous.

4.—*Genus.*—LEIOPTERIA, *Hall*, 1882.

(35th Ann. Report N. Y. State Cabinet Nat. Hist., p. 406c.)

Leiopteria? australis, sp. nov.

(Pl. XIX, Fig. 19.)

Sp. Char.—Shell sub-rhomboidal, oblique, longer than wide, produced postero-ventrally. Hinge-line straight, less than the width of the shell; ligamental area narrow. Left valve feebly convex in the umbonal region, the latter subtending an acute angle, the surface becoming much flattened towards the ventral margin, which is obliquely rounded. Anterior end or ear, small, limited by a very undefined sulcus; anterior margin oblique, insinuated in the middle, thence broadly curving to the ventral margin. Posterior end, or wing, triangular, flattened, the extremity pointed; posterior margin more or less sigmoidal; posterior ridge obtuse; sculpture not preserved, but no trace of radii.

Obs.—The specimen figured is an internal cast of the left valve, and does not appear to be specifically related to any previously described Australian Palæozoic shell. It is quite distinct from Dana's *Cypricardia acutifrons*†, although the latter may possibly be generically related. It is almost superfluous to say that Dana's species is not a *Cypricardia*.

Locality and Hor.—Dungog Road, nineteen miles from West Maitland, Parish of Barford, County of Durham (*J. Waterhouse*, M.A.).—Carboniferous.

5.—*Genus.*—LEPTODOMUS, *McCoy*, 1852.‡

(Brit. Pal. Foss., 1852, Fas. 2, p. 277.)

Leptodomus duplicicosta, sp. nov.

(Pl. XIX, Figs. 20 and 21.)

Sp. Char.—Shell transversely oblong; valves moderately convex, most so at about half the distance between the anterior and posterior margins. Hinge-line, or dorsal margin, straight; ventral margins gently convex, the curvature only faintly

* 13th Ann. Report State Geol. N. York for 1893 [1894], II, p. 780.
† Wilkes' U.S. Explor. Exped., X, Geology, 1849, t. 8, f. 4, A and B
‡ Non *Leptodomus*, McCoy, 1844.

interrupted by the cinctures; anterior margins rounded; posterior margins rounded below, rather obliquely truncated above. Diagonal ridges obtusely rounded; posterior slopes convex anteriorly, concave posteriorly, with a shallow median groove; cinctures shallow and faint, and without a succeeding fold; lunule apparently small and inconspicuous; umbones depressed and incurved. Sculpture very characteristic, and strongly marked, consisting of coarse strong costæ, simple anteriorly, and as far as a point in a line with the umbones, from this point widely bifurcate, and on passing over the diagonal ridges seem to have been somewhat echinate; intervening valleys shallow.

Obs.—This little shell is remarkable not only for the strength and paucity of its concentric costæ, but also for the remarkably strong bifurcation of the latter. Succeeding costæ may be bifurcate, or every alternate one, or only every third costa. Traces of an epidermis are visible on one portion of the specimen. *L. duplicicosta* possesses somewhat the appearance of two shells called by De Koninck *Palæarca interrupta*,* and *P. subarguta*,† but is distinguished by the characters already given.

Locality and Hor.—Maitland Colliery Shaft, near West Maitland (*J. Waterhouse* M.A.).—In hard nodules of the Upper Marine Series, Permo-Carboniferous, sixty to ninety feet from the surface.

XXVI.—Stratigraphical and Palæontological Notes, No. 1: by W. S. DUN, Assistant Palæontologist.

I.—Devonian Fossiliferous Beds at Eden.

I AM indebted to Mr. J. E. Carne for the following notes on the occurrence and discovery of Devonian fossils in the sandstones at Bell Bird Creek, three miles north of Eden. Shells were first noticed by J. Hall while quarrying road-metal at the above-mentioned locality, on the Pambula Road. One of these shells was forwarded to Mr. Carne, at that time engaged on the Border Prospecting Survey at Delegate, and others were afterwards collected by one of the Prospecting Party. In August Mr. Carne visited the locality, and collected a number of specimens, among which were undoubted *Rhynchonella pleurodon*, Phillips; also a large species of *Rhynchonella*, imperfect, with very strongly marked ribs. This is very close to *R. cuboides*, Sby., a common European Devonian species, though, on the other hand,

* Foss. Pal. Nouv.-Galles du Sud., Pt. 3, 1877, p. 287, t. 16, f. 5,
† *Ibid.*, p. 287, t. 16, f. 8.

there is a possibility of its being one of the extreme variations of *R. pleurodon*. There are also a few imperfect specimens of *Atrypa*, very like some small forms of *A. reticularis*, Linn. Indefinite traces of a small branching Polyzoan are also present.

The fossils occur in a much indurated, in places felspathic, sandstone, which is very hard, and varies from a fine grained to a coarse grit. From its position it must form one of the lower members of the Devonian series, overlying the Upper Silurian (?) rocks of the district. These Devonian sandstones and conglomerates alternate with very ferruginous roughly cleaved clay-slates, which, from their distinctive red and purple colouring, form a very marked surface feature. Close search has yielded no trace of organisms in the last-mentioned beds.

The fossiliferous sandstone has a dip of N 61° E, at an angle of 15°, and a strike of N. 29° W. The bed is characterised by ripple marks and annelid markings, and is probably of shallow water deposition.

This is the first occasion on which the age of these beds has been decided on palæontological evidence. A detailed account of the general geology of the Eden District will be found in a Report by Mr. Carne.* These beds were classed as Devonian by the Rev. W. B. Clarke.† Mr. E. F. Pittman,‡ in a report on the District in 1880, states that he was of opinion from their lithological character that the more horizontally-bedded deposits might be either of Triassic age, or similar to the Devonian of North Gippsland; the resemblance to Triassic sandstones was also noted by Mr. Clarke. The lower series Mr. Pittman classed as Silurian. Mr. W. Anderson§ classed the whole series, with the exception of a conglomerate bed at the top—which he considered to be Devonian—as Silurian. Mr. Carne's observations bear out the view that at Eden the lower beds are Silurian, and the more horizontal sandstones, conglomerates, and slates as Devonian.

II.—Permo-Carboniferous beds in the Kempsey District.

In 1892, Mr. E. W. Rudder submitted to the Department some Permo-Carboniferous fossils from a locality six miles west of Kempsey. These were:—

Spirifera.
Fenestella.
Deltopecten cf. illawarrensis, *Morris.*
Trachypora Wilkinsoni, *Eth. fil.*

In 1896 Mr. J. E. Carne collected a few specimens from Ph. Willi Willi, Co. Dudley, and Mr. C. Cullen shortly after collected from this Parish, and also from Ph. Warbro, a large number of undoubted Permo-Carboniferous forms. These

* Ann. Rept. Dept. Mines and Agric. N. S. Wales for 1896 [1897], pp. 109–112.
† Southern Gold-fields, 1860, pp. 191–194.
‡ Ann. Rept. Dept. Mines for 1880 [1881], p. 244.
§ Ann. Rept. Dept. Mines N. S. Wales for 1890 [1891], p. 263.

were preserved mostly in limestone of which there appears to be considerable development, both in thickness and area, and also in associated shales. This is as far as I am aware the first recorded instance of large deposits of Permo-carboniferous limestone in New South Wales, though limestones are well-developed in the underlying Carboniferous Beds. The limestone fauna comprises:—

SPONGIDA.—Traces of a sponge, preserved as casts of elongated simple spicules, possibly *Lasiocladia*.

There are also some long isolated simple spicules that may be the anchoring spicules of *Hyalostelia*.

CŒLENTERATA.—Zaphrentis gregoriana, *De Kon.*
Zaphrentis, sp.

There are also numerous casts of a very ramose coral which appears to be a stout variety of *Cladochonus tenuicollis*, McCoy. *Stenopora tasmaniensis*, Lonsdale (?).—Some small casts of a Monticuliporoid are taken to be a small variety of this species. There is also a larger species in which the corallites are arranged very obliquely along the central axis.

POLYZOA.—Fenestella internata, *Lonsdale.*
„ fossula, *Lonsdale.*
„ propinqua, *McCoy* (?).
Protoretepora ampla *DeKoninck.*
Phyllopora (cf. Retepora? laxa, *DeKoninck.*)

BRACHIOPODA.—Martiniopsis subradiata, *Sby.*
„ oviformis, *McCoy* (?).
Spirifera tasmaniensis, *G. Sby.*
„ vespertilio, *G. Sby.*
„ sp?
Productus semireticulatus, *Martin* (?).
„ brachythærus, *G. Sby.*
„ cf. undatus, *Defrance.*
Strophalosia, sp. indet.

PELECYPODA.—Eurydesma cordata, *Morris.*
Deltopecten illawarensis, *Morris.*
Aviculopecten squamuliferus, *Morris.*

From this list it will be seen that taking all the species into consideration there can be no doubt that the facies is Permo-Carboniferous. On the other hand, there is also a mixture of Carboniferous forms with the others. It is impossible to say at present whether these beds belong to the Upper or Lower Marine Group, though I think there is a great probability of their being eventually proved to be Lower.

In the various geological maps of the Colony there have been several changes in the correlation of the formations in this district. In that published in 1880, issued by the late C. S. Wilkinson, and compiled from the Rev. W. B. Clarke's original map, the country immediately around Kempsey is coloured as Devonian. A strip of this extends for about twenty miles to the north and five to the south, along the western portion of this is marked a bed of limestone nearly twenty miles long and presumably Devonian also. (Part of this is probably the area under discussion in this note.) On either side of the Devonian area upper Silurian deposits are shown extending for a considerable distance to the north; a patch of granite bounds it on the north, Coal Measures on the south, and there are patches of basaltic rocks on either side. This disposition of formations is retained in the geological map issued in the 1882 edition of the "Mineral Products."

On the map issued by the same authority in the second edition of the "Mineral Products," published in 1887, the sole change is that the Upper Silurian deposits shown on the 1880 and 1882 maps are mapped as Devonian.

In the latest geological map of the Colony, that published under the direction of Mr. E. F. Pittman in 1892, this same tract of country is coloured as Upper Silurian.

De Koninck* describes from this district the following fossils, which he classes as Devonian:—

Favosites polymorpha, *Goldf.*
Strophalosia productoides, *Murchison.*
Chonetes hardrensis, *Phillips.*
,, coronata, *Conrad.*
Atrypa reticularis, *Linn.*
Aviculopecten Etheridgei, *De Koninck.*
,, McLeayi, *De Koninck.*

These specimens, collected about forty years ago by the Rev. W. B. Clarke, were unfortunately destroyed by fire in the Garden Palace fire in 1882. From this district there are at present no specimens from either Devonian or Silurian beds in the collections, the nearest Devonian area represented by fossils being on the Pigma Barney River, near its junction with the Manning, whence Mr. G. A. Stonier collected specimens of *Favosites*. Mr. Carne informs me that he is of opinion that the Willi Willi and Warbro beds rest unconformably on an older series consisting of highly-inclined slates, which are either Upper Silurian or Devonian. Up to the present, as far as I am aware, no fossils have been found in these slates, so that their correlation is based on lithological evidence only.

* Foss. Pal. N. Galles du Sud, 1875, II., pp. 79, 83, 85, 87, 97, 114.

III.—The Occurrence of Graptolites in the Peak Hill District.

The Mining and Geological Museum is indebted to Mr. F. Danvers Power for several specimens of a bluish grey lustrous slate, showing numerous graptolites, from Myall Reefs, near Tomingley, in the Peak Hill District. These are much distorted and preserved as white films, with the outlines of the hydrothecæ preserved but in rare instances. Some of them are undoubtedly Diprionidian forms, though some may be imperfectly preserved Monoprionidians. These slates, up to the present considered to be barren, have been mapped as Upper Silurian, and unfortunately the fossil evidence is too unsatisfactory to enable the matter to be settled definitely as yet, as *Diplograptus* forms occur in both Lower and Upper Silurian rocks, though more characteristic of the former. Upper Silurian Graptolites have been found in New South Wales at Bowning, by Mr. John Mitchell.* The Rev. W. B. Clarke also remarks† that "one is said to have been found in this Colony, and I presume it is more likely to belong to the Upper Silurian than to the Lower"; but does not mention the locality of the occurence.

Additional specimens obtained by Messrs. Power and Card, while this was going through the Press, prove beyond doubt that these slates contain Graptolites of a Lower Silurian facies, *Climacograptus* and *Dicellograptus.*

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MAITLAND (A. G.)—Notes on the Pikedale Gold-field. *Bull. Geol. Survey Q'land*, 1895, No. 2, p. 10.

MESCHINELLI (A.)—Sylloge fungorum fossilium hucusque cognitorum. Pp. 72, Patavii, 1892. *Fide* M. Staub, *Neues Jahrb für Mineralogie*, 1896, I, Refr., pp. 361–363. [References to Australian Fossil Fungi.]

VIS (C. W. de)—On the Mandible of *Zygomaturus*. *Proc. R. Soc. Q'land*, 1895, XI, p. 1, pp. 5–11.

Correction.

Record for 1895.

P. 90, line 15, for X read IX.

XXVIII—Kalgoorlite—a new Telluride Mineral from Western Australia: by E. F. PITTMAN, A.R.S.M., Government Geologist.

DURING an official visit to Western Australia in October last I had an opportunity of examining the rich telluride deposits of Kalgoorlie. These occur as intrusive dykes of a very crushed and foliated or schistose igneous rock, which has been examined in thin sections under the microscope by Mr. G. W. Card, A.R.S.M., Mineralogist to the Geological Survey, and has been described by him as a quartz-felspar-porphyry. The telluride minerals occur as veins, splashes, and pockets in this rock, and have evidently been deposited in the spaces between the folia by ascending solutions.

Amongst the tellurium minerals occurring in these mines, at least two distinct varieties were conspicuous at the time of my inspection. One of these minerals was of a dark—almost black colour, and in this respect offered a strong contrast to the other which was of a pale yellow. It was a matter of difficulty to obtain a sufficient quantity of either mineral in a state of purity to enable a complete analysis to be made, but I am indebted to W. F. Grace, Esq., Manager of the Lake View and Boulder Junction G. M. Co., for a small sample (slightly over one gramme) of each.

The dark mineral has a specific gravity of 8·791. It is massive, and has a sub conchoidal fracture. Colour, iron black.

A quantitative analysis was made by Mr. J. C. H. Mingaye, F.C.S., Analyst to the Geological Survey of N.S.W., and yielded as follows :—

Mercury	10·86	
Gold	20·72	
Silver	30·98	
Copper	·05	
Sulphur	·13	
Tellurium	37·26	(by difference).
	100·00	

It is clear from Mr. Mingaye's analysis that the composition is different from that of any mineral hitherto recorded. The empirical formula calculated from the above figures is $Hg. Au_2. Ag_6. Te_6$. I propose to name the mineral "*Kalgoorlite*," after the celebrated gold-field in which it occurs.

It is stated that a specimen of native amalgam was found in the Boulder Perseverance Mine, Kalgoorlie, last year, and it is probable that it was derived from the decomposition of this mineral, Kalgoorlite.

An analysis of the pale yellow mineral was also made for me by Mr. J. C. H. Mingaye, with the following results :—

Gold	=	41·76	
Silver	=	·80	Specific gravity.
Tellurium	=	56·65	9·377
		99·20	

The ubstance is therefore identical with *Calaverite*, the percentage of silver being rather less than that hitherto recorded for this mineral. The specific gravity is also correspondingly higher, as might be expected. It would appear therefore that calaverite may be regarded as a telluride of gold with a variable proportion of telluride of silver.

PLATE XVI.

Syringopora bellensis, *Eth. fil.*

Fig. 1. The corallum, showing the mouths of the corallites protruding through the connecting floors at more than one level.

Fig. 2. Nine corallites, surrounded by the youngest connecting floor. x 1½.

Fig. 3. Two corallites, with the inwardly bevelled margins, forming vestibules as it were. x 4.

Fig. 4. Three corallites, seen in elevation and partial section, showing the rows of spiniform septa. x 2½.

Fig. 5. Two corallites, seen from the outside, also in elevation, with a side view of one connecting floor. x 2.

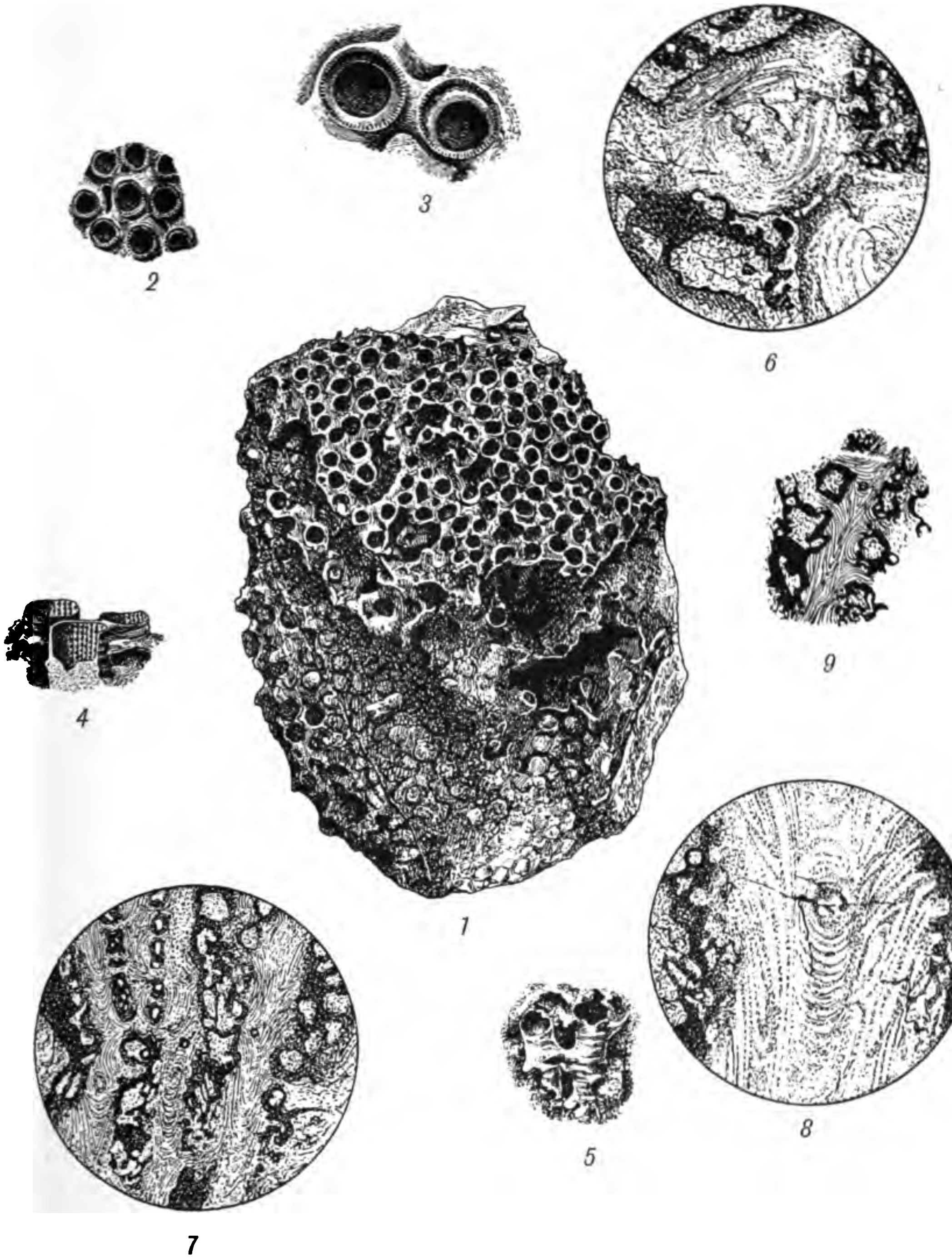
Fig. 6. Horizontal section of two ill-defined corallites, exhibiting the concentric cut edges of the infundibuliform tabulæ. x 10.

Fig. 7. Vertical section of parts of five corallites, showing the infundibuliform tabulæ, the endothecal tissue in the interiors of the connecting floors, and the interstitial free spaces between the latter. In the central long corallite is visible the cylindrical tube with its concave septa. x 3.

Fig. 8. The tabulate portion of the cylindrical tube seen in Fig. 7. x 12.

Fig. 9. Portion of a corallite in vertical section exhibiting the bending down of the infundibuliform septa to form the cylindrical tube. x 4.

Drawn from nature by Mr. F. R. Leggatt.



Frank R. Leggatt, del.

PLATE XVII.

Fig. 1. *Schizophoria*, sp. ind.

Figs. 2, 12, 13, 14, 17. *Spirifera Jaqueti*, Dun.

Figs. 3, 5. *Schizophoria convexa*, Dun.

Fig. 4. *Rhynchonella*, sp. ind.

Fig. 6. *Athyris*, sp. ind.

Fig. 7. *Rhynchonella* (?).

Fig. 8. *Orthoceras*, sp. ind.

Fig. 9. *Pentamerus* (?).

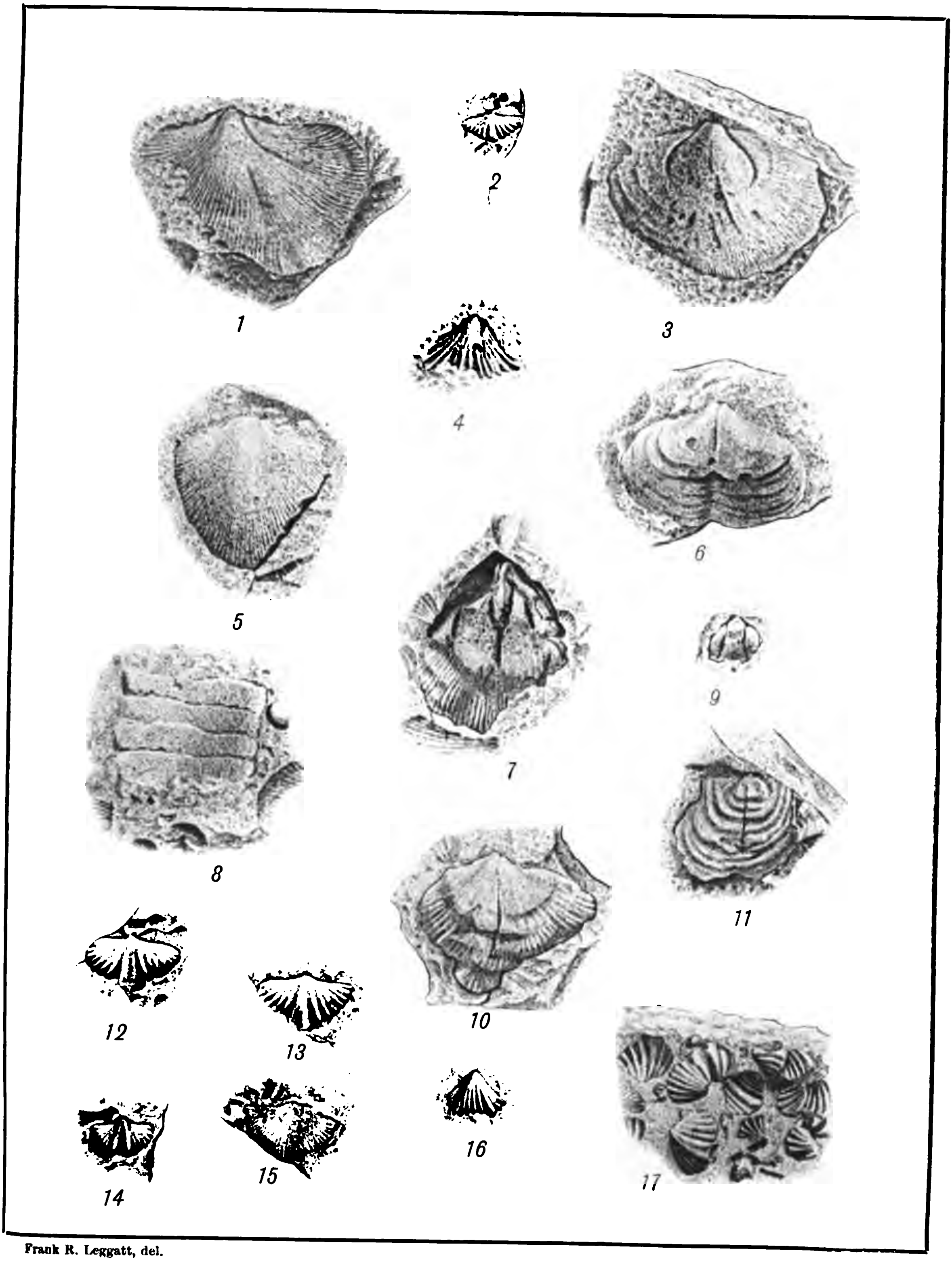
Fig. 10. *Spirifera*, sp. ind.

Fig. 11. *Leptæna rhomboidalis*, Wilck (?).

Fig. 15. *Chonetes*, sp. ind.

Fig. 16. *Rhynchonella pleurodon*, Phillips.

All from the White Cliffs Opal Fields. Drawn from nature by Mr. F. R. Leggatt. Of natural size.



Frank R. Leggatt, del.

PLATE XVIII.

Fig. 1. ***Grammysia***, sp. ind.

Fig. 2. ***Orthonota***, sp.

Fig. 3. (Fig. 6 ?) ***Leptodesma inflatuia***, Dun.

Fig. 4. ***Pterinea*** (?).

Figs. 5, 7. Gen. et. sp. indet.

Fig. 8. ***Lyriopecten gracilis***, Dun.

Figs. 9, 10. ***Tentaculites***, sp. ind.

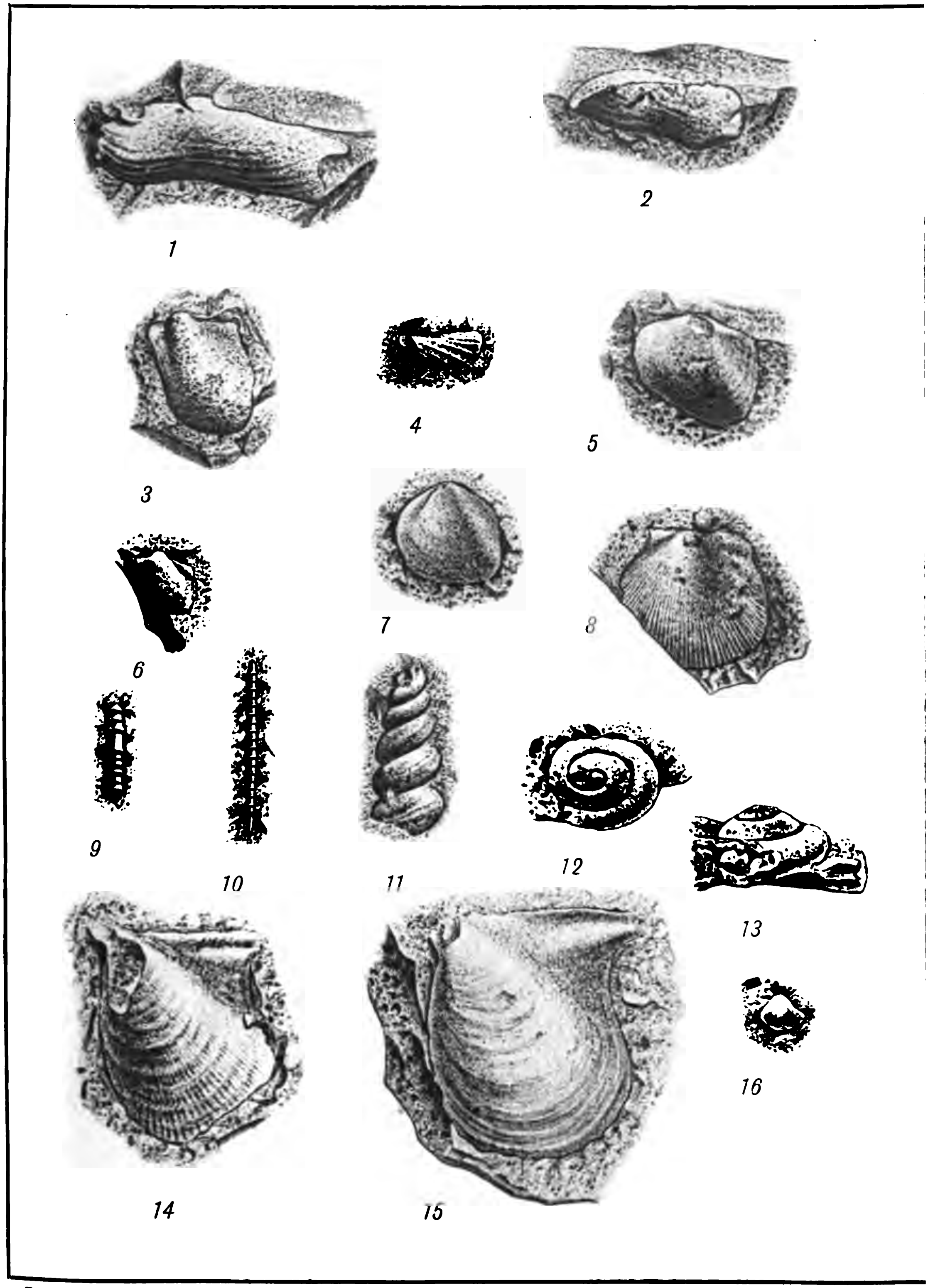
Fig. 11. ***Murchisonia***, sp. ind.

Figs. 12, 13. ***Euomphalus Culleni***. Dun.

Figs. 14, 15. ***Actinopteria*** australis, Dun.

Fig. 16. ***Goniatites***, sp. ind.

All these specimens are from the White Cliffs Opal Fields. Drawn from nature by Mr. F. R. Leggatt.



Frank R. Leggatt, del.

PLATE XIX.

Dielasma inversa, *De Koninck, sp.*

Fig. 1. Side view of united valves. Harper's Hill.
Fig. 2. Dorsal view of Fig. 1.
Fig. 3. Ventral view of Fig. 1.
Fig. 4. Side view of another specimen. W. Maitland.
Fig. 5. Dorsal view of Fig. 4, with slit left by the septum.
Fig. 6. Ventral view of Fig. 4.
Fig. 7. A broader variety, dorsal view. W. Maitland.
Fig. 8. Ventral view of Fig. 7.
Fig. 9. Side view of Fig. 7, showing the lateral curvature of the dorsal valve.
Fig. 10. Dorsal view, showing cavities left by the dental plates and impression of muscular platform, &c. W. Maitland.
Fig. 11. Wax impression taken from Fig. 10, with the muscular platform well shown.
Fig. 12. Side view of an elongated variety resembling De Koninck's figure. West Maitland.
Fig. 13. Dorsal view of Fig. 12.

Platyschisma oculus, *J. de C. Sowerby, sp.*

Fig. 14. Back view of a depressed variety, with only two whorls seen in a side view. Harper's Hill.
Fig. 15. Front view of Fig. 14, with the umbilicus visable.
Fig. 16. View of the base of Fig. 14, displaying the delicate cancellation of the surface.
Fig. 17. The obtuse peripheral keel of Fig. 14, magnified, exhibiting the backward flexure of the oblique threads.

Actinoconchus planosulcatus, *Phillips, sp.*

Fig. 18. A valve partially embedded in matrix with portions of two of the calcareous laminar plates and their component spines, enlarged. Düngog Road.

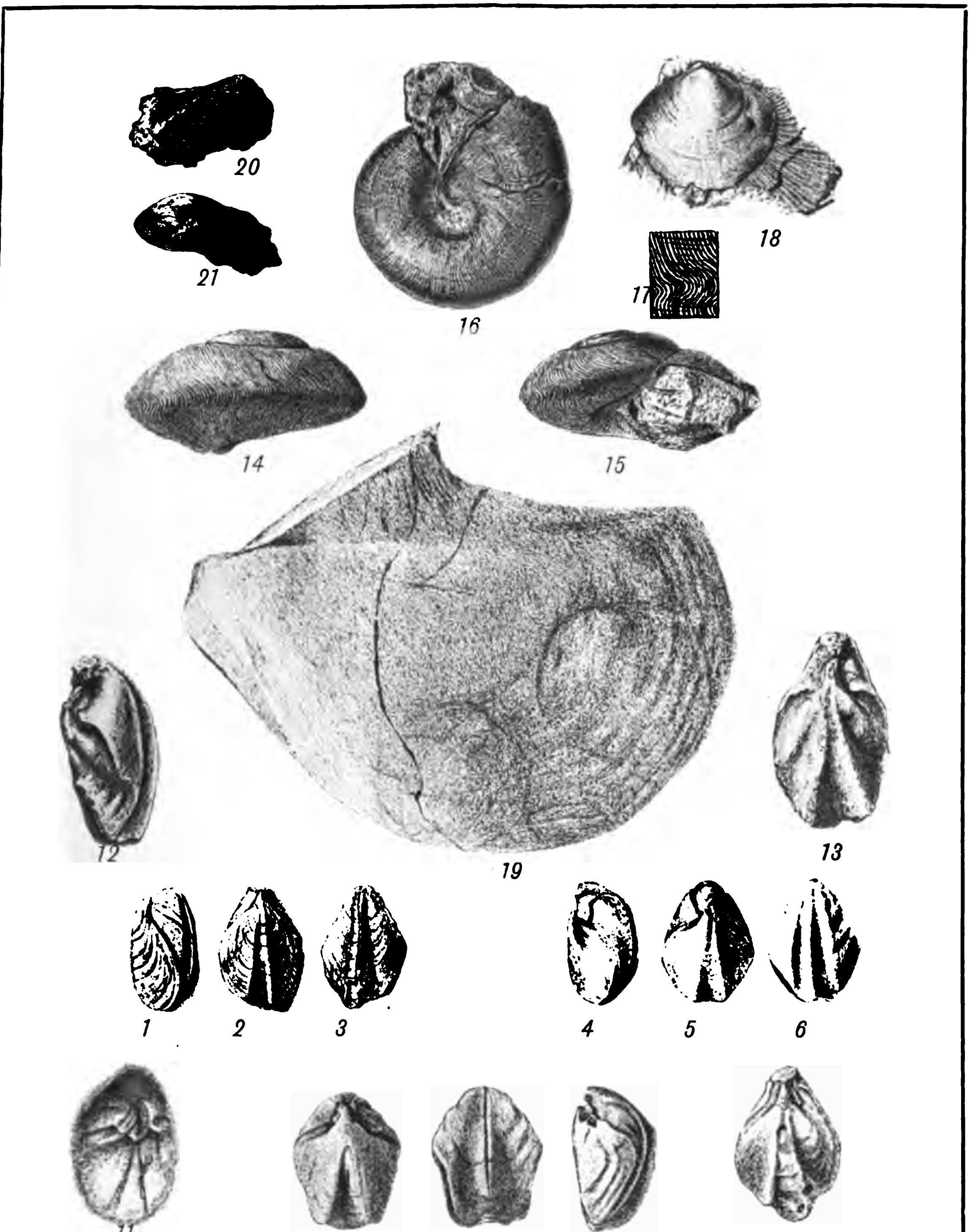
Leiopteria ? australis, *Eth. fil.*

Fig. 19. Left valve, internal cast. Dungog Road.

Leptodomus duplicicosta, *Eth. fil.*

Fig. 20. Side view of a right valve displaying the bifurcate costæ. Maitland Colliery.
Fig. 21. Dorsal view of Fig. 20.

Drawn from nature by Messrs. P. T. Hammond and F. Leggatt.



T. P. Hammond, del.

DEPARTMENT OF MINES AND AGRICULTURE, SYDNEY.

RECORDS

OF THE

GEOLOGICAL SURVEY OF NEW SOUTH WALES.

VOL. VI.

1898-1900.

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Page 56, line 11. For *14·1* read *1·41*.
Page 59, line 6. For *84·49* read *89·49*.
Page 60, line 12. For *26* read *2·6*.
Page 182, line 16. For *E. and F.* read *Eth. fil. and Foord.*
Page 217, line 2. For *Blaney* read *Blayney*.
Page 217, line 12. For *41* read *141*.
Page 218, line 6. For *Jinberbyne* read *Jinderbyne*.
Page 218, line 22. For *Blaney* read *Blayney*.
Page 218, line 12. For *Goodna* read *Gooda*.
Page 233, line 26. For *Blaney* read *Blayney*.
Page 236, line 29. For *Blaney* read *Blayney*.
Page 252, line 27 For *Blaney* read *Blayney*.
Page 248, line 10. For *Blaney* read *Blayney*.
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Page 257, line 6. For *Euabolong* read *Euabalong*.
Page 257, line 39. For *Galley* read *Gally*, and add "*or Gully*"
Page 258, line 25. For *Grey Mares* read *Grey Mare's*.
Page 262, line 15. For *Moonbie* read *Moonbi*.
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Page 294, line 18. For *2691* read *270*.
Page 294, line 30. For *169* read *159*.
Page 297, line 26. Add *Southern Gold-fields, pp. 272-273*.
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Page 304, line 20. For *Blaney* read *Blayney*.
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Page 355, line 33. For *1895* read *1893*.
Page 355, line 38. For *59* read *60*.
Page 356, line 13. For *156* read *146*.
Page 356, line 15. For *64* read *65*.
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Page 353, line 20. For *1882* read *1883*.
Page 353, line 24. For *Bushby* read *Bushy*.
Page 354, line 6. For *47* read *27*.

DEPARTMENT OF MINES AND AGRICULTURE, SYDNEY.

RECORDS

OF THE

GEOLOGICAL SURVEY OF NEW SOUTH WALES.

Vol. VI.] September, 1898. [Part 1.

I—Notes on the Geology and Mineral Deposits of Portions of Western Australia: by EDWARD F. PITTMAN, A.R.S.M., Government Geologist.*

I.—Physiography and Geology.

THE south-western portion of Western Australia is composed mainly of an elevated table-land, the western escarpment of which is formed by the Darling Range. This table-land reaches an altitude of about one thousand four hundred feet (at Coolgardie) and the rocks of which it is composed are chiefly granites and crystalline gneisses with occasional belts of metamorphic schists, and dykes of diorite or other hornblendic rocks.

West of the Darling Range, which is composed of the rocks just mentioned, are patches of Mesozoic sediments, but the coastal district, in the centre of which the city of Perth stands, consists of undulating country formed of a calcareous sand-rock of undoubted Æolian origin. The surface of this country is almost everywhere covered with a considerable thickness of fine loose sand, while occasionally along the shoreline, as at Fremantle and other points to the north of it, and also at Subiaco between Fremantle and Perth, the calcareous sand-rock may be seen outcropping. It consists of a very porous rock composed of angular grains of sand and fragments of shells loosely cemented. In places, as at Subiaco, there may be seen imbedded in the sand-rock irregular shaped masses of limestone, evidently produced by the action of rain-water containing carbonic acid which has dissolved the shell fragments and re-deposited the carbonate of lime in segregated masses.

* Read before the Aust. Assoc. Adv. Sci., Sydney Meeting, January, 1898.

There are no traces of regular bedding visible in this deposit of sand-rock, but the natural sections which occur along the coast, as at Fremantle, and in several railway cuttings exhibit very characteristic false bedding, the grains of sand having been disposed along planes which clearly represent the "angle of repose" of mounds of loose sand, and which therefore point to its windblown origin.

This rock has been assigned a Post Tertiary age by West Australian Geologists, because of its containing the remains of marine shells and crustaceans which are identical with existing species. As far as I could ascertain, however, these fossil remains have not been found anywhere except along the coast where the rocks have been exposed to the sea, and I observed that many pot-holes in the rock along the shore-line had been filled with recent shells, which had evidently become cemented to the sides and now form part of a solid deposit. It is just possible, therefore, that all the fossil remains hitherto noticed may have had a similar origin, and that this Æolian deposit may really be of Tertiary age.

Along the coast in some of the points to the North of Fremantle, and also in the banks of the Swan River, the weathered rock presents a very beautiful aspect. The carbonate of lime has here been deposited through it in pipes or stalactitic forms, and the weathering has resulted in the sand grains being removed, leaving a fantastic network of calcareous stalactites which cross and interpenetrate in all directions, causing the cliff to assume the appearance of being covered by the most beautiful lacework.

The calcareous sand-rock of the coastal district has been, and is being extensively used for building purposes in Perth and Fremantle, and it is also utilised as a a foundation for roads, being afterwards covered with ferruginous gravel. The rock is very soft when freshly quarried, but hardens on exposure, and appears to stand well in buildings. It has also been exclusively used in the construction of the large moles or breakwaters, which form such a conspicuous feature in the Fremantle Harbour improvements now being carried out under the supervision of Mr. C. Y. O'Connor, Engineer-in-Chief for Western Australia. At first sight it would appear almost incredible that such porous rock would resist the action of the waves, but experience shows that it answers the purpose admirably.

II.—The Perth Artesian Water Supply.

The chief interest, however, which attaches to this Æolian sandstone, from a geologist's point of view, is due to the fact that it yields a fine artesian water supply. The width of this coastal strip of artesian water-bearing rocks in an east and west direction is about fifteen miles. It reaches from the flanks of the Darling Range, near the Midland Junction Railway-station, to the sea, and it is believed to extend along the coast, to the north and south, for many hundred miles, forming a belt of rather low undulating country, the surface of which is composed of sand-hills.

At Guildford, three miles to the west of Midland Junction, a plentiful supply of water under pressure was obtained at a depth of about four hundred feet, while at Perth a supply of five hundred thousand gallons per day was struck, at a depth of about eight hundred feet. The source of the supply is the rain-water (averaging between thirty and forty inches per annum) which falls upon the western slopes of the Darling Range, and which is absorbed by the sands at its base, and sinks into the underlying calcareous sand-rock. As showing the extremely porous nature of this country, it may be mentioned that many creeks issue from the foot of the Darling Range carrying strong bodies of water which completely disappear before reaching the coast fifteen miles to the west. Quite a number of bores are now being put down for the purpose of utilising this underground water-supply.

The islands off the coast, such as Rottnest, Garden Island, &c., are said to be composed of the same Æolian rock, and it is therefore evident that there must be a leakage of the artesian water into the Indian Ocean. The altitude of Perth above sea-level is thirty-eight feet; that of Midland Junction is but forty-four feet; Bellevue, three miles further east, is fifty-seven feet; while Swan View, which is only three miles eastward of the latter place, has an altitude of two hundred and sixty-eight feet. From Swan View, the Darling Range, composed of granite and gneiss, rises rapidly to a height of one thousand feet above sea-level. There is one noticeable feature in the Perth artesian water *basin*, if it may be so called, wherein it differs materially from the ideal artesian basin described in text-books. It lacks the overlying impervious beds which are so often quoted as necessary for keeping the underground water in a state of pressure, and preventing its escape to the surface. It is true that around Perth there are patches of clay under the sandy soil, in places; but these are of local occurrence, and there do not appear to be any continuous beds which can be regarded as impermeable. In an interesting paper read before the Royal Society of New South Wales,* Professor David exhibited an experiment which illustrated the reason why, in a one-sided artesian basin having leakage to the sea (like that of Queensland and New South Wales), the water was under sufficient pressure to rise above the surface, in bores. He proved that the resistance offered by the sands and gravels through which the water was obliged to percolate before it reached the sea, was sufficient to maintain the pressure necessary to force the water to the surface when bores were put down.

It appears evident that the same principle can be extended to explain why the artesian water in the Perth basin, although not covered by any continuous impermeable stratum, occurs under sufficient pressure to enable it to rise above the surface in the bores. The water in this case has to meet not only the resistance offered by the sand-grains in its passage to the sea, but also the resistance offered

* Journ. R. Soc. N.S. Wales, 1893, XXVII., p. 428. "Notes on Artesian Water in N.S. Wales and Queensland," by T. W. E. David, B.A., F.G.S., Professor of Geology, Sydney University.

to its upward ascent by the overlying beds of calcareous sand-rock. In short, if sand-rock, porous though it be, offer such resistance to the lateral flow of water it will offer even greater resistance to its vertical ascent. It appears possible, therefore, to have a complete artesian basin, without any impermeable covering stratum, provided the porous intake beds outcrop at a sufficient altitude above the site of the bore-holes to supply the necessary "head."

III.—The Collie Coal-field.

I was able to make only a brief inspection of the Collie Coal-field, which is situated in a valley in the Darling Range, about one hundred and ten miles to the south of Perth, and about thirty miles to the east of the seaport of Bunbury, with which it will shortly be connected by railway. The Coal-field has an altitude of about 600 feet above sea-level. Unfortunately it does not offer many facilities, in the way of natural sections, to the geologist, for it consists of undulating country, the lower portions of which are for the most part covered by sand; while the hills are capped by a horizontal deposit of tufaceous conglomerate, which is a marked surface feature of the whole of the south-west portion of the Colony, and which may, probably, be of Pleistocene age. Along the banks of the Collie River, conglomerates and sandstones are visible in a few places, but there does not appear to be any continuous section which would allow the sequence of the beds to be observed. The Coal-measures evidently rest in a basin the floor of which is composed of granite, and the known Coal-seams have been discovered either by boring or by sinking near the northern margin of the field,—for their outcrop is in every case hidden by the surface accumulations of sand, &c.

A coal-seam of considerable thickness (twelve or thirteen feet) I was informed, was opened in what is known as the Government Mine, and about five hundred tons of coal have been extracted by an inclined shaft or tunnel following the dip of the seam, which is more or less in a southerly direction. These workings being now full of water could not be inspected. A second seam is visible in a shaft at a depth of about seventy feet, in an adjoining property. This seam consists principally of carbonaceous shale, in the midst of which is a small seam of coal not thick enough to be economically worked. A number of other seams are said to have been discovered by boring; but as the only evidence supplied was the material brought up,—for the most part in a fine state of division,—it is probable that some of these seams may have partly consisted, like the one already mentioned, of carbonaceous shale.

There appears to have been a considerable amount of controversy as to the quality and age of the Collie coal, some authorities having asserted that it is a true Palæozoic coal, while others have contended that it is a lignite. As a matter of fact it shows no ligneous or woody structure, but has all the appearance, as

well as composition and other characters, of a coal of Mesozoic age. It is lustrous, bituminous, and fairly firm when newly won; but appears to become rather friable on exposure, due, no doubt, to the amount of water it contains. It burns well, leaving a bulky ash, which, however, is very light. Its worst features are that it contains a high percentage of water, and that it does not form a coke.

The average of a number of analyses of this coal made by Mr. B. Woodward, of the Perth Museum, is as follows:—

Water	11·60	
Volatile Hydrocarbons	32·10	
Fixed Carbon	51·20	
Ash	4·35	
Sulphur	0·90	Specific gravity ... 1·30

One of the most unsatisfactory features of this coal-field, from a mining point of view, is the fact that the Coal-measures form an artesian water basin. All the bores that were put down in the deep ground, *i.e.*, towards the dip of the Measures, struck artesian water, which may still be seen rising above the surface under considerable pressure. While, therefore, it may be possible to extract a fair amount of coal from near the outcrops, it is manifest that the working of these seams in the deep ground, where a large supply of water exists under pressure, would not be practicable.

The occurrence of artesian water in these Coal-measures is further evidence in favour of their Mesozoic age, as it has not hitherto been met with in Palæozoic coal basins.

Although shales are abundant in the spoil-heaps about the mines, they are singularly barren of fossil-plant remains, and, after a careful search, I was only able to obtain two fragments of leaves. These appeared to have somewhat the outline of *Glossopteris* though they were too imperfect for their shape to be definitely determined. The venation showed a few examples of anastomosis, but not nearly so many as *Glossopteris*, and the midrib was not by any means well defined. The specimens were submitted to Mr. Robert Etheridge, jun., of the Australian Museum, for his opinion, and he reported as follows:—

"I do not think the fossils represent leaves of a *Glossopteris*, nor am I at all sure that they belong to the allied genus *Gangamopteris*, although the midrib, or what can be seen of it, has some resemblance to that of the latter. There remains, then, with us, the Mesozoic genus *Sagenopteris*, and to this, I suggest, the fossil may possibly belong."

It will be seen, therefore, that the evidence of the fossil-plant remains (imperfect though they are) is in favour of the Mesozoic age of the Collie Coal-field, and thus supports the evidence which is supplied by the character of the coal itself and the geological peculiarities of the basin.

In the "Mining Handbook of Western Australia," by H. P. Woodward, Esq. (late Government Geologist), it is stated that Mr. Robert Etheridge, sen., F.R.S. of London, reported having found portions of *Glossopteris* or *Noeggerathia* in a sample of coal from the Collie Field, and that on this evidence he assigned a Palæozoic age to the coal. Mr. Woodward also informed me that in a subsequent report Mr. Etheridge withdrew this statement. It is possible, therefore, that the fragment seen by Mr. Etheridge, senr., may have been a small portion of *Sagenopteris* showing some net venation, and that this characteristic may have led him to the erroneous conclusion that the plant was the Palæozoic one *Glossopteris*.

In view of the somewhat inferior quality of the Collie Coal, and in view also of the difficulties in the way of economic mining, caused by the occurrence of artesian water in the coal basin, it is rather surprising that so much money has been spent on this field, while other districts along the coast to the north appear to be of greater promise. As an instance of this it may be stated that in the Perth Museum there is a collection of fossils which point to the existence of Permo-Carboniferous Coal-measures in the Gascoyne district, and there is, therefore, good reason for expecting that prospecting there would result in the discovery of coal similar to that of Newcastle.

Coolgardie Gold-field.

Coolgardie is situated about three hundred and fifty miles to the east of Perth, on the table-land previously mentioned, and has an altitude of about fourteen hundred feet above sea-level. The railway from Perth crosses the Darling Range at an altitude of one thousand feet, and then traverses a wide area consisting chiefly of granite with occasional belts of metamorphic schists. At the town of Coolgardie the granite and quartz porphyry are seen to junction with hornblendic rocks, and there is a considerable development of amphibolites, hornblende schists, diorites, &c. Several important lodes, such as Bayley's and the Londonderry, occur near this line of junction. They may be described as large bodies of white quartz in which gold has been found in phenomenally rich "chutes," which were, however, of limited dimensions, and which were separated by barren or very low grade material. At the Londonderry Mine a coarse pegmatite occurs which very much resembles that found so commonly at Broken Hill, except that it contains a yellowish-green variety of mica. About three miles west of the Londonderry Mine, a rock of similar character contains large crystals, up to six inches in diameter, of *Lepidolite* or lithia mica, which may prove to be of commercial value.

Many of the quartz reefs in the neighbourhood of Coolgardie stand up from the surface like walls of masonry, fifteen or twenty feet high, having resisted the denuding action of the atmosphere better than the enclosing country rocks. As a general rule, the outcrops of such reefs have not proved payable, but experience has shown that on this field, as in so many others in the Eastern Colonies, the gold,

for the most part, occurs in "chutes." Over-capitalisation of many mines appears to have been the outcome of the assumption that these rich "chutes" were of unlimited dimensions. There are a fair number of reefs in the Coolgardie Gold-field which have yielded consistent returns, and many others have a promising appearance. Other auriferous deposits, locally known as "formations," occur on this field. They consist of lenticular-shaped lodes, or dykes, up to ten feet in width at the surface, which thin out as they descend, and which consist of a very decomposed kaolinised material intersected by quartz-veins. The veins carry coarse gold, while the kaolinised lode-stuff contains the precious metal in a fine state of division. It is probable that they are dykes of quartz-felspar porphyry, though I was unable to see any of the undecomposed rock, owing to the fact that the workings have not been carried to a sufficient depth. The walls consist of actinolite rock. It is probable that if these deposits were explored to greater depths they would be found to increase in width again. In one instance I saw free gold in a rock which appears to be almost entirely composed of actinolite.

The hills about Coolgardie are capped by a thickness of from ten to fifteen feet of an agglomerate or gravel consisting for the most part of angular fragments of the surrounding rocks, but also containing some waterworn pebbles. In places this deposit becomes very ferruginous and passes into limonite. It may be of later Tertiary or Pleistocene age.

The valleys between the hills have received material derived from the denudation of these gravels, as well as from the underlying rocks and quartz reefs, and over a considerable area they have been proved to contain rich, but, for the most part, shallow auriferous alluvials, which have been worked several times over by the method known as dry blowing, as water is too scarce to allow of any other process.

That these valleys have had, at one time, deep outlets, is proved by the fact that at a place known as Rollo's Bore, about 2 miles east of Coolgardie, a well has been sunk for a depth of 400 feet through alluvial clays. A thin bed of lignite was penetrated near the bottom, and this contained numerous impressions of the leaves of Eucalypts, the appearance of which points to the probability of the valley having been filled up in Pleistocene times. There is reason for supposing, therefore, that this country enjoyed, during comparatively recent geological times, a much greater rainfall than it receives at the present day, and which is estimated at about five inches per annum. Moreover, it is only reasonable to suppose that the gold derived from the denudation of the reefs must have been carried into these deep drainage channels, none of which appears to have been prospected.

A very large amount of money has been fruitlessly expended at Coolgardie in the attempt to discover artesian water by boring with a diamond drill in solid granitic rocks. This undertaking was, I understand, carried out in opposition to

the advice of all the geologists who were consulted; and it is needless to add that the result was unsuccessful. The bore was abandoned after a depth of three thousand feet had been reached.

Auriferous Cement Deposits.

About thirty miles in a northerly direction from Coolgardie a number of mines have been worked in an auriferous deposit which is locally known as "cement." It consists of a loose white, or greyish-white sandstone, cemented by kaolin in greater or less proportion, and containing subangular fragments of quartz, with occasional well-rounded quartz pebbles. Near the top of the deposit is a bed of kaolin about six inches thick, with a half-inch band of sand. The formation, which is horizontally bedded, is overlaid by ferruginous gravel, similar to that about Coolgardie, and it occurs as a capping (having a maximum thickness of about fifteen feet) to a number of low granite hills. It contains angular fragments of free gold of varying size, some of them being microscopic, but is only payable along certain fairly-defined channels. The bed rock (granite) of these channels contains numerous pot-holes, showing that the "cement" was laid down on a denuded surface. I was informed that the richest deposits of gold are not, as a rule, found in the bottom of these holes, but around their margins—which appears remarkable. Some of the cement has proved remarkably rich, containing at the rate of eighty ounces to the ton; but this is, of course, exceptional, and the auriferous channels do not exceed thirty feet in their widest parts. The cement, in places, has been converted (possibly by hydro-thermal action) into a vitrified rock, which has very much the appearance of the well-known "Desert Sandstone" (Upper Cretaceous) of Queensland and New South Wales, in which the interstices between the grains of sand have been filled by secondary silica. Several hand specimens of this rock which I had an opportunity of examining in Sydney two years ago, led me to express the opinion that it was really the Desert Sandstone. After an inspection of the deposit *in situ*, however, one can have no hesitation in recognising it as an alluvial deposit resulting from the disintegration of granite. The gold has evidently been derived from the denudation of quartz reefs, several of which occur in the vicinity. The best of these reefs has a thickness of about eighteen inches, and has yielded at the rate of about ten ounces per ton. The angular nature of the gold can be accounted for by the fact that it has had but a short distance to travel. No fossils have been found in the "cement," and it is therefore impossible to determine its age; but it is clearly older than the ferruginous gravels which occur about Coolgardie, and may therefore be provisionally put down as late Tertiary.

Kalgoorlie Gold-field.

The township of Kalgoorlie is situated about twenty-five miles in a north-easterly direction from Coolgardie, and is reached by the main line of railway from Perth, a distance of three hundred and seventy-four miles. The name "Kalgoorlie" has

already become famous by reason of the extraordinarily rich auriferous deposits which occur in its neighbourhood. Gold was first discovered by a prospector named Hannan, close to the present township of Kalgoorlie, and a very considerable area of surface or shallow alluvial deposits, derived from the denudation of quartz reefs which intersect a low range in the vicinity, have been worked and reworked by "dry blowers."

The principal interest, however, in the "Kalgoorlie," or, as it is officially termed, the "East Coolgardie" gold-field, centres in what are commonly known as the "Telluride deposits." These occur at a locality named the "Boulder," distant about four or five miles in a south-south-east direction from Kalgoorlie, and they form a series of low hills, which in fact are a continuation of the range previously alluded to as occurring in the vicinity of Kalgoorlie township. The country to the east, west, and south of this range consists of plains, the geological formation of which is obscured by superficial deposits of sand, gravel, and travertine, and which support a vegetation consisting of low scrub, and stunted Eucalyptus trees. Of the latter, two varieties are known locally as "Salmon Gum" and "Gimlet Gum." About four miles south of the Boulder is situated "Hannan's Lake," a large depression or "clay pan," in which no water is to be seen except after a heavy rainfall, which is not of frequent occurrence.

A considerable supply of extremely salt water however is conserved in the alluvial sands and clays which form the bed of the lake, and this is pumped to the Boulder through long lines of pipes, and is utilised for mining purposes. The bed of the lake glistens with crystals of gypsum and salt, and all the water in tho district (with the exception of that obtained by distillation for domestic purposes) is extremely saline; it is nevertheless exclusively used for both battery work, and wet extraction in the Cyanide plants.

The Boulder hills, where the telluride deposits occur, are covered, at their summits, with horizontal deposits of ironstone gravel, which passes, in places, into compact limonite. The Great Boulder Mine, which was the first established, received its name from the occurrence of large masses of this ironstone, which stand out on the top of the hill forming part of its surface. Immediately under this deposit the hills are composed of what at first sight appear to be bluish-grey micaceous or talcose schists, and these in places are intersected by dykes of diorite, and also by irregular quartz reefs. These "schistose" rocks, though having the appearance of what is generally known amongst mining men as "country rock," were found, by the earlier miners, to contain free gold, which in places was extremely rich. Some of the gold was fairly coarse, but much of it presented a very deceptive appearance, and could easily be mistaken for a coating of dull yellow clay. This is now known at the mines as "mustard gold." As these auriferous rocks were followed down, and as the shafts were intersected by cross-cuts,

it was noticed that the unproductive country at the sides was indistinguishable in character from the lodestuff, except in the matter of its unproductiveness. In short, there was always a difficulty in determining the limits of the so-called "lodes," and this could only be done, where free gold was not visible, by calling in the assistance of the assayer.

The zone of oxidation, within which the rocks have been subjected to more or less decomposition by the action of the atmosphere and by the percolation of water from the surface, extends, in these hills, to a depth varying from eighty to two hundred feet. Below this zone iron pyrites appears in the rocks and this is accompanied, in a number of the principal mines, by tellurides of gold and silver and mercury. Tellurides were, I believe, first recognised in the mine known as Block forty-five, but there appears to be a dispute as to whom the credit of the discovery is due. Ores of tellurium and gold are now also known to exist in the "Great Boulder, the "Boulder Main Reef," "Lake View Consols," "Ivanhoe," "Australia," "Boulder Perseverance," "Kalgurli," "Kalgurli North," "Brookman's Boulder," and "Golden Horseshoe" mines. The greatest depth attained in any of the mines up to the present is a little over three hundred feet, and a careful examination of the workings from the surface down to this depth, leads one to the following conclusions:—(1) That the so-called lodes are in reality intrusive dykes, and (2) That the material of the walls, or "country" is of precisely similar origin, and differs merely in the proportion of its mineral contents, and the amount of alteration it has undergone.

There is a gradual transition, downwards, from the talcose, schistose-looking rocks of the surface, to the dense bluish-green rock which is found in the lower levels, and which has the appearance to the naked eye of a characteristic quartz felsite. It is thus evident that the surface rocks are merely the result of the oxidation of those below, just as the free gold contained in the former is the product of the decomposition of the pyrites and telluride minerals of the latter. I may state here that I collected a number of samples of so-called "lodestuff" and "country rock" from the principal Boulder mines, and these have been examined in thin sections under the microscope by Mr. G. W. Card, Mineralogist to the Geological Survey. He finds (as was indeed fairly evident to the naked eye) that "the evidence obtained by examining and comparing as many slides as possible shows that the country rocks from the different mines on the field, differing as they do in colour, structure, &c., are one and the same rock; and further, that the lodestuff itself is nothing but an extremely altered form of the same."

Mr. Card further states that—"The divisional planes exhibit a silvery sheen, due to the development of secondary mica. That this rock is of igneous origin is evident from its mineralogical constitution and structure. Quartz, felspar, ilmenite and magnetite are among the original constituents, and that characteristically

igneous structure, the micropegmatitic, so common among the acid eruptives, is sometimes well shown. The green colouration is due to chlorite, which acts as a pigment when finely disseminated—as it generally is. When chlorite is absent the rock is lighter in colour."

There is abundant evidence that these rocks in the Boulder Mines have been subjected to an enormous amount of crushing, which has induced in them a highly schistose structure. This is especially noticeable in the productive portions or "lodestuffs." which are in places quite fissile or foliated. Tellurides of gold, silver, and mercury are distributed through the lodestuff in veins, splashes, and pockets, and in the offices of the mine managers some very fine specimens are to be seen containing solid masses of Tellurides sometimes nearly an inch in thickness. As these minerals contain as much as forty-one per cent. of gold, the presence of a small proportion of them has the effect of imparting a high assay value to the stone. Occasionally metallic gold is seen in conjunction with Tellurides, and in one instance a vugh in the deposit was found to enclose large masses of beautiful sponge gold, probably derived from the decomposition of Tellurides.

The productive dykes, or "lodes" as they are locally termed, are frequently intersected by irregular quartz reefs. These reefs, in which the quartz is white and crystalline, sometimes follow the strike of the dykes, at other times cut across them, and occasionally enter the walls. They are not continuous for any distance, and their width varies very considerably. They sometimes, but not always contain free gold.

It is probable that they represent fissures which have been formed by the contraction of the dykes when cooling, and which have subsequently been filled in by ascending solutions of silica. The dykes are also characterised by numerous ironstone veins, consisting of specular iron and limonite, which branch off from the productive portions or "lodes" into the walls. These veins are probably the source of the ironstone gravel which forms such a noticeable feature on the surface of the Boulder Hills. The joints of the lode-stuff in the lower levels are frequently coated with carbonates of lime and magnesia, while in the oxidised zone their place is taken by gypsum. Among other minerals observed in the dykes may be mentioned Magnetite in fairly large crystals, Iron Pyrites and Arsenical Pyrites. Chloride of Silver is stated to have been found in considerable quantity in one of the mines near the surface. In some places kaolinisation of the felspars in the lode-stuff has taken place to a considerable extent. I was informed by Mr. T. A. Rickard, State Geologist of Colorado, that Vanadium Mica had been recognised in some of the rocks from the Boulder, and this statement is supported by the fact that Mr. J. C. H. Mingaye, Analyst to the Department of Mines, has detected Vanadium in some of the material collected by me.

The area within which the productive dykes have, so far, been proved to exist is about three-quarters of a mile wide, and its length is about a mile and a quarter. Fresh discoveries, however, continue to be made at intervals, and it is possible that they may be found to extend considerably beyond these limits.

Within this area quite a number of more or less parallel "lodes" or productive belts occur, being separated by belts of unproductive rock of similar origin. The strike of the principal productive belts varies from N. 30° W. to N. 50° W., but these are in places cut off and sometimes faulted by other dykes of similar material which cross them almost at right angles.

The productive portions of the dykes are nearly vertical, but as a general rule they have a slight underlay to the W.S.W., while occasionally the dip changes to E.N.E. for short distances.

Well-defined walls are not seen in these deposits, but occasionally on one or other side of an ore body there is a fairly smooth plane which marks the limit of the productive stone. In the Boulder Main Reef Mine, between the ore body and what may be termed the hanging wall, there is a thickness of about six inches of what appears to the naked eye to be a brecciated rock. Mr. Card, however, after examining a thin section of this material under the microscope, reports that "it would appear as if the breccia-like appearance were delusive, and were due to the unequal distribution of the chlorite."

In some instances drives have been continued in payable ore for a distance of nearly half a mile along a dyke. The productive belts vary considerably in width, though they are rarely less than one foot. From four to six feet is not an uncommon width, and they increase from this to as much as thirty-five feet or more.

In one of the principal mines the following section was exposed in a cross-cut:—

	35 feet wide.	30 feet wide.	15 feet wide.	4 feet.	14 feet wide.	
West.	Average assay value about 2 oz.	Barren.	Average assay value, 3-4 oz.	Barren.	Average assay value, 3-4 oz.	East.

So that in a total width of ninety-eight feet, no less than sixty-four consisted of high-grade ore.

It has not yet been proved how far this extremely rich deposit continues in the direction of its strike, though one of the drives is at least sixty feet long. The newspapers record that a shipment of one thousand tons of ore from this mine was recently treated for a yield of slightly over four thousand ounces of gold.

So far as I could ascertain there has not been any notable decrease in the richness of the ore bodies as they descend. On the contrary, in some mines the value of the ore appears to have increased in the lower levels. However, as the greatest depth hitherto attained is only a little over three hundred feet it would be risky to predict that no impoverishment will take place as the excavations are carried downwards. Indeed, it will be more reasonable to expect that the auriferous ores will be found to occur in chutes, as is the case in so many true lodes.

A considerable amount of controversy was aroused when the first traces of tellurides were discovered in Block 45, by a statement made by Mr. Maryanski, a mining engineer, to the effect that the permanence and richness of the Kalgoorlie lodes were now assured. This may, perhaps, appear to be a bold assumption when based on the mere presence of a small quantity of tellurium mineral; but when the mode of occurrence of the tellurides in the three hundred feet levels is studied, when they are seen to be disseminated through dykes of igneous origin, there are, I think, reasonable grounds for expecting that the enrichment of the deposits by these minerals will continue, probably with intermissions, to very considerable depths. Should they prove to do so, and should their richness be maintained at anything like its present grade, the output from the Kalgoorlie Mines, when efficient ore-reduction plants have been provided, should be something phenomenal, for one cannot avoid the conclusion that here there is an area of about one square mile which, on present indications, promises to contain some of the richest gold deposits in the world.

The total output of gold from the Kalgoorlie Gold-field for the year 1895 is stated to have been thirty-six thousand ounces, in 1896 it was about one hundred thousand ounces, and for 1897 it rose to over three hundred thousand ounces.

Another point about the productive belts in the Boulder dykes is that they occasionally split up or "fork," and the two branches, after diverging for some distance, again unite, enclosing a lens-shaped "horse" of unproductive material.

Along the western side of the Boulder field, and parallel to the dykes, there extends a narrow belt of jasperoid and chalcedonic rocks of varying colours, and in conjunction with this is a bed of black carbonaceous slate. These rocks are seen outcropping near Hannan's Lake, where they stand up from the surface like a wall. An examination of this outcrop shows that in places the slate is in process of replacement by white chalcedony. Neither the jaspers nor the slates are visible on the surface far north of Hannan's Lake, but they have been met with in shafts in several places along the west of the principal mines, thus proving the continuity of the beds for at least four miles. It seems probable that these jaspers, &c., mark a contraction fissure along the western boundary of the dykes, and that the silicification has been caused by the ascent of thermal solutions along the course of the fissure.

With regard to the genesis of the metalliferous deposits at the Boulder, there is much room for speculation, but, in view of the limited extent of the present excavations, it is difficult to advance a perfectly satisfactory theory as to their origin. There is, however, little doubt that the productive belts have been subjected to a great deal of crushing, which has produced the schistose or foliated structure so characteristic of them, and it seems reasonable to suppose that the gold, silver, mercury, and other metals together with the tellurium and sulphur have been derived from solutions which deposited them between the folia of the shattered rock.

The question as to whether the deposition of the minerals has resulted from "lateral secretion" or from "ascension" of such solutions is one which will require more investigation than is possible at present, but, in view of the dense character of the unproductive rocks adjoining the productive belts, I venture to think that, if the ore deposits be due to lateral secretion, the leaching of the precious metals from the enclosing rocks must have taken place at a lower level than has, as yet, been reached in the mine workings.

The surrounding district affords a fairly liberal supply of wood suitable both for mine timber, and for fuel. Owing, however, to the difficulties of carriage, the mine managers, as a rule, prefer to employ imported coal for steam raising.

Undoubtedly the most serious difficulty to be overcome in connection with the Kalgoorlie Mines is the absence of a good supply of water. It has been already stated that the salt water obtained from the bed of Hannan's Lake is largely employed for mining purposes. The balance of the available supply is derived from the underground workings of the mines, and there seems to be little doubt that this will, at no distant date, prove inadequate. The source of mine-waters is the rain which percolates through the more or less porous rocks within the zone of oxidation, and collects above the undecomposed rocks. As the workings progress in depth, therefore, the supply of water must be expected to diminish in these mines, in accordance with the experience of other mining districts all over the world.

The water from the Boulder Mines is said to contain free sulphuric acid, (derived from the decomposition of pyrites) which necessitates the use of limestone to neutralise it, before it can be employed in the Cyanide Vats. I was informed that, about seven pounds of limestone are used per ton of ore treated.

The Government having recognised the necessity for providing a water supply for these gold-fields, the Engineer-in-Chief, Mr. C. Y. O'Connor, has recommended a scheme for pumping five million gallons per day from the Greenmount Ranges to a reservoir on the top of Mount Burgess, near Coolgardie, whence the water would flow by gravitation to the fields. The distance which the water would have to be pumped is three hundred and thirty miles, and the vertical height which it

would have to be raised is one thousand three hundred and fifty feet. Nine pumping stations would be required, and the steel pipes would be laid on the surface of the ground, as the soil is so saturated with salts that they would be rapidly corroded if laid underground. The estimated capital cost of the scheme is two million five hundred thousand pounds, and the working expenses are set down at three hundred and twenty thousand pounds per annum. It is also estimated that the scheme would allow of water being sold at the rate of three shillings and sixpence per one thousand gallons.

At present only the oxidised ores, in which the gold is free, are treated locally. These are for the most part reduced and amalgamated in stamper batteries, the tailings being subsequently treated by the Cyanide process.

In the Australia Mine, however, the ore after being crushed in rock breakers, is heated to expel moisture, and then ground in Krupp Mills. The greater part of the gold is then extracted in cyanide vats, and the tailings from these passed into Huntingdon Mills in which the coarser gold which remains (about three dwt. per ton) is obtained by amalgamation. A very good extraction is, it is claimed, obtained by this system.

At present the only mine which is provided with a reduction plant at all commensurate with its ore reserves, is the Lake View Consols. This Company has sixty head of stamps, forty of them being provided with the most modern accessories. The ore is conveyed by an elevated wire tramway to the battery, and the tailings are conveyed from the latter to a cyanide plant.

Many of the other mines will shortly be provided with modern reduction plants, so that a marked increase in the production of gold can be anticipated.

The telluride ores from the lower levels are at present sold, on the basis of their assay value, to the smelting works at Port Pirie, Dry Creek, and Lake Illawarra, where they are smelted with silver-lead ores, the resulting product being bullion containing lead, gold, and silver. Experiments on the treatment of the telluride ores by roasting and cyaniding have been made at the mines, and it is stated that successful results have been obtained. It is probable that local works will be erected on these lines, though there is reason for supposing that the very rich concentrates will be more economically treated by smelting.

It is only natural to expect that in the neighbourhood of such rich auriferous matrices as those which occur in the Kalgoorlie field, alluvial deposits resulting from the denudation of the lodes and dykes should also occur. For a long time, however, it appears to have been thought that there were no ancient drainage channels of any depth, and that consequently no deep auriferous leads could exist. Until quite recently, therefore, alluvial mining was confined to the shallow or surface deposits, and these were worked with considerable profit by dry blowing. These shallow deposits rest on a smooth floor of greyish-white travertine, which,

for a long time was regarded by the miners as "bed rock." In September last, however, some more than usually-enterprising prospectors at Kanowna, about twelve miles from Kalgoorlie, broke through the travertine, which proved to be only a thin stratum, and which was found to be underlaid by made ground consisting of angular fragments of stone, with a few rolled pebbles. By following this down, an extremely rich gutter was discovered resting upon a floor of decomposed quartz porphyry.

This lead was worked into deep ground, widening out as it was followed, and at the time of my visit had been proved payable at a depth of fifty feet, and was still going deeper. The gold is very angular, as a rule, indicating that it has not travelled far in contact with hard rocks; but the fact of its occupying an ancient drainage channel is undoubted.

The existence of the deep ancient valley which was proved by Rollo's Well, near Coolgardie, and which I have already alluded to, is interesting in this connection, and I have very little doubt that deep leads, equally as rich as the one at Kanowna, will yet be found in the neighbourhood of the Boulder dykes. There is evidence of deep ground to the south-west of the mines, and a creek (dry except in rainy weather) which trends towards Hannan's Lake, has cut its course through a fluviatile deposit of ironstone gravel some feet in thickness, which proves that a much greater rainfall occurred in former times. It can scarcely be doubted, therefore, that the denudation of these rich dykes has been followed by the concentration of the gold in alluvial gutters.

In conclusion, I may refer to the varieties of the telluride minerals hitherto found in the Boulder Mines.

In the Journal of the Chemical Society for November, 1893, * a reference is given to an analysis, by M. August Frenzel, of a mineral from Kalgoorlie, which he identified as sylvanite, or graphic tellurium.

Two distinct minerals were fairly plentiful in the mines at the time of my visit. One of these was of a pale-yellow colour, while the other was of an iron-black. No crystal forms were observed, and it was a matter of some difficulty to obtain a sufficient supply of either variety, in a state of purity, to enable an analysis to be made. I am, however, indebted to Mr. W. F. Grace for a sample of the pale-yellow mineral which has been analysed by Mr. J. C. H. Mingaye (Analyst to the Geological Survey of New South Wales), and has proved to be calaverite.

The analysis gave—

Te.	56·64	
Au.	41·76	
Ag.	·80	
	99·20	Sp. Gr. 9·377

* LXXI & LXXII., No. CCCCXX, p. 503.

With regard to the darker tellurides, there may be more than one variety. Mr. T. A. Rickard (State Geologist of Colorado) informs me that he has recognised coloradoite—a telluride of mercury—at Kalgoorlie; and quite recently Mr. W. F. Grace forwarded me a sample of mineral which proved to be a telluride of gold, silver, and mercury, with a trace of copper. Mr J. C. H. Mingaye has made a quantitative analysis of this mineral, which I have named Kalgoorlite, *Vide* Records of the Geol. Survey of N.S.W., V., Part IV., p. 203.

I was informed that telluride deposits had been found at Lake Lefroy, about twenty-five miles S.S.E. of the Boulder, and also near Broad Arrow, twenty-five miles to the N.N.W. It is significant that these two localities are on the line of strike of the Boulder dykes, and this would appear to indicate that the intrusions have taken place along a line of weakness, the extremities of which are at least fifty miles apart. It is quite probable, therefore, that other deposits of tellurides may be discovered along the course of this line.

I desire to record my thanks to a number of gentlemen in Western Australia for many courtesies which greatly facilitated my work. Amongst these may be mentioned Mr. Wittenoom (Minister for Mines), Mr. Crockett (Acting Under Secretary), Mr. O'Connor (Engineer-in-Chief), Mr. H. P. Woodward, Mr. Maitland (Government Geologist), Messrs. Simpson, Blatchford, and Becher, of the Geological Survey, and the managers of the various mines.

II.—Notes on the Country Rock of the Kalgoorlie Gold-field, Western Australia, with a Bibliography: by GEORGE W. CARD, Assoc. R.S.M., F.G.S., Curator and Mineralogist.

[Plates I–III.]

THROUGH the courtesy of Mr. E. F. Pittman, Government Geologist for New South Wales, and Mr. W. Frecheville, the Writer has had an opportunity of examining specimens collected by them from the Kalgoorlie Gold-field during the latter part of 1897. In October of that year an examination of some of Mr. Frecheville's specimens revealed the inadequacy of the references to the Kalgoorlie country rock that had previously appeared in print. Mr. Frecheville thereupon very kindly placed the whole of his collections at my disposal for examination, and as the work proceeded it has been a frequent matter of regret that I did not

make a fuller use of the opportunity. Mr. Frecheville's notes on his specimens are incorporated in an interesting paper* read before the Institute of Mining and Metallurgy, in February, 1893.

The general interest that has been taken in this field on account of its promising character and the occurrence of the precious metal in the form of telluride, together with the uncertainty that has prevailed as to the true nature of the country rock and of the lode-stuff, has seemed a sufficient justification for describing the specimens,—all of which are now in the collections of the Mining and Geological Museum, Sydney. While it is hoped that the publication of these notes may throw some light upon a difficult subject, it is fully recognised that very much more work will be necessary both in the field and in the laboratory before the story can be written in any degree of completeness. Evidence of special value may be hoped for from an examination of the rocks met with in cross-cutting through barren ground,—the evidence afforded by the examination of the specimens that form the subject of these notes leading me to hope that comparatively fresh rock may be met with at no great distance from the ore bodies. A geological survey of the field will shortly be commenced by the staff of the Geological Survey, Western Australia, and as this survey and the opening-up of the mines proceeds, much that is now obscure will doubtless be made clear.

About fifty thin sections, very carefully prepared by Mr. C. Murton, have been examined, and I am indebted to Mr. Malcolm Morrison for the whole of the specific gravity determinations, and for other assistance. The examination has been prolonged and more difficult than it would otherwise have been by reason of the continual interruptions to which official duties necessarily render one liable.

Previous references:—The specimens of Kalgoorlie ore received in Sydney from time to time being schistose in structure, it at first seemed probable that the country was of that nature. In mining reports the terms "slate" and "schist" are found used in connection with the deposits.

Mr. S. Göczel, in his report to the Minister for Mines, Western Australia,† on the Coolgardie District, says,—"A large break in the country, consisting principally of coarse-grained diorite, extends over six miles from N.N.E. to S.S.W., near the township of Kalgoorlie and encloses a countless number of lodes."

Mr. H. Y. L. Brown, who visited the field in its early days (October, 1895), speaking of the Kalgurli Mine says‡ (p. 2),—"The rock formation here consists of talcose, argillaceous, and chloritic schists, clay slate, hornblende slate, and hornblende rock, with dense and crystalline diorite dykes, and decomposed dykes of a granitic character." Portions of the lodestuff from the Lake View and Boulder East are

* Notes on a visit to the Gold Mines at Kalgoorli, Western Australia. Trans. Inst. Mining and Metall., London, 1898. Reprinted in the Mining Journal, LXVIII, No. 3264, pp. 310, 311.

† Report on the Mines, Coolgardie District. *Ad interim* Rept. Dept. Mines W. Austr. for 1894 [1894], p. 20.

‡ Auriferous Deposits of Western Australia. S. Austr. Parl. Paper, No. 26, 1896.

described as resembling decomposed granite. In describing the Maritana Mine Mr. Brown says (p. 8),—"A rock resembling decomposed granite rock . . . is looked upon as the chief auriferous formation," and refers to "undecomposed hornblendic and dioritic rocks."

In his Annual Progress Report for 1896, Mr. A. G. Maitland, Government Geologist for Western Australia, says,*—"The Kalgoorlie gold-field consists chiefly of schists, intersected by dykes and masses of igneous rock the exact nature of which has not yet been determined."

Herr Schmeisser in his report on the Gold-fields of Australia to the German Government† makes brief references to Kalgoorlie. Speaking of the country rocks of the West Australian gold deposits, he refers to Kalgoorlie along with Coolgardie, Yilgarn, and the Murchison as occurring in crystalline schists of Archean age. After commenting on the loose use of the word "diorite" by the miners,‡ and deciding to name most of the rocks so designated as amphibolites, Herr Schmeisser gives a list of the localities from which he took specimens for examination, in which are included three from Kalgoorlie, viz., Great Boulder Mine, two hundred feet level; Ivanhoe Mine, one hundred and ninety-three feet level; Hannan's Brown Hill, one hundred and ninety-eight feet level. There then follows a general description of the amphibolites, in which stress is laid upon the presence of strongly pleochroic hornblende. It does not appear what specimens the description particularly applies to, and it may be that those from Kalgoorlie were classified by their appearance only and were not examined microscopically. He considers that the amphibolites may be due to the effects of pressure metamorphism on eruptive diabase. Mica-schist, talc-schist, and phyllite are referred to as forming the country rock in some localities. It seems clear that Herr Schmeisser regarded the Kalgoorlie deposits as occurring in a more or less schistose amphibolite.

Mr. Frank Reed, Inspector of Mines, Western Australia, makes the following remark§:—"In connection with the dioritic schist-rock, which is a characteristic of the Western Australian Gold-fields, the writer may state that this formation originally consisted of massive diorite or diabase, but by tangential dynamic pressure it has assumed a schistose form. These dioritic schists occur as breaks in the Archean gneiss and granite, and form the country-rock of the West Australian Gold-fields."

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* Ann. Rept. Dept. Mines W. Austr. for 1896 [1897], p. 27.

† Die Goldfelder Australasiens. Berlin, 1897.

‡ *Op. cit.* p. 43. "Die westaustralischen Golderzlagerstätten im Gebiete der krystallinischen Schiefer erwecken in geologischer und wirthschaftlicher Beziehung ein besonderes Interesse. Als Nebengestein einer grossen Anzahl von Golderzgängen tritt in weiter Verbreitung daselbst ein Gestein auf, welches örtlich von den Bergleuten kurzweg "Diorit" genannt wird. Dieser Bezeichnung würden körnige Plagioklas-Hornblendegesteine entsprechen. Kommen auch im Murchison-Distrikt solche echte Diorite als Nebengesteine der Gänge vor, so erscheint doch die Mehrzahl der sogenannten Diorite, wie der Untersuchung einer grossen Anzahl von uns an Ort und Stelle entnommer Gesteinsproben ergeben hat, als mehr oder minder vollkommen geschieferte Gesteine, welche wesentlich aus Hornblende bestehen. Sie werden daher am besten als Amphibolite bezeichnet."

§ Hydrothermal gold-deposits at Peak Hill. Western Australia. Trans. Fed. Inst. Mining Eng., 1897, XIV, Pt. 1, p. 92.

Mr. H. P. Woodward, late Government Geologist for Western Australia,* refers to a range in the neighbourhood consisting of "hard fine-grained hornblendic schists, intersected by numerous diorite dykes." He describes the deposits as "a series of fissures formed without yawning, gaping, or faulting, up which lightly heated mineral solutions were forced which permeated the country rock on each side of these cracks, dissolving out certain of its constituents, and replacing them by others, thus altering the nature of the rock to a large extent near the fissure and gradually less further and further from it until no alteration at all took place, where the country rock remained in its original form."

Mr. E. F. Pittman, in a report to the Minister for Mines,† read as a paper before the Australian Association for the Advancement of Science at the Sydney meeting in January, 1898, concludes (p. 140), "(1) That the so-called lodes are in reality intrusive dykes, and (2) that the material of the walls, or 'country,' is of precisely similar origin, and differs merely in the proportion of its mineral contents and the amount of alteration it has undergone." Mr. Pittman continues—"There is a gradual transition, downwards from the talcose schistose looking rocks of the surface, to the dense bluish-green rock which is found in the lower levels, and which has the appearance, to the eye, of a characteristic quartz-felsite." Throughout the lodes are referred to as dykes, and this portion of the report concludes as follows:—"There is little doubt that the productive belts have been subjected to a great deal of crushing, which has produced the schistose or foliated structure so characteristic of them; and it seems reasonable to suppose that the gold, silver, mercury, and other metals, together with the tellurium and the sulphur, have been derived from solutions which deposited them between the folia of the shattered rock."

Mr. George J. Bancroft, in a paper‡ read before the American Institute of Mining Engineers at the February meeting, 1898, speaks as follows:—"The diorite extends for miles in all directions. But there are two dikes, one at the south-west corner, and one at the north-east corner of the field. They are at some distance from the rich mines, but pieces of float which I picked up indicate that there may be others nearer the center of the camp. Prof. J. F. Kemp, of the Columbia School of Mines, has determined the dike-rock to be a pyroxenite composed mostly of tremolite or actinolite.

"Associated with the veins are lenticular bodies of graphitic slate. These have been called eruptives by some; but Prof. Kemp has determined the rock to be a true slate, probably an altered and metamorphosed clay-rock.

* The so-called Lode Formation of Hannan's. Mining Journal, 1897, LXVII, No. 3248, p. 1,369.

† Notes on the Geology and Mineral Deposits of portions of Western Australia. Ann. Rept. Dept. Mines and Agric. N. S. Wales for 1897 [1898], pp. 136-143.

‡ Kalgoorlie, Western Australia, and its Surroundings.

"The rich area of Kalgoorlie is characterised by a bluish tinge of the rocks, while the rocks of the barren ground surrounding it have a greenish tinge. The local mineralogists have considered the two shades as different alterations of the same rock, and have given the name diorite to both.

"It has been suggested that the blue stone is a later eruptive, and that to the influence of this eruption the mineralisation of the camp was due, Prof. Kemp has determined the blue-stone to be a much altered basic-eruptive, which is now serpentine and chlorite. The green-stone, as determined at Perth, is essentially the same, except that there is a little olivine present. Both rocks are so greatly altered that it is difficult to determine exactly what they were originally, so that there is no conclusive evidence that the blue-stone is, or is not, a later eruptive.

"The veins are mineralised bands in a schistose country." Further on the writer says, "The ore is very slightly-altered country rock."

In the paper* above referred to, Mr. Frecheville gives the following admirable description of the country rock:—"Two prominent varieties of country rock were noticed in going through the mines. One, forming the country rock of the western mines, such as the Ivanhoe, Golden Horseshoe, Great Boulder, and Lake View, and also, the predominant country rock of the whole belt, is a fine-grained, green, massive rock of only moderate hardness, being easily scratched by a knife, with a homogeneous appearance,—although on looking very closely into it, very minute specks of glassy quartz, of a black metallic-looking mineral, and an occasional speck of pyrites, can be seen here and there. The other rock, of a grey appearance, was noted in the more eastern mines, such as the Australia, Kalgoorli, &c. This rock has also generally a homogeneous appearance, and, although of a distinct colour, has a good deal of resemblance to the green variety, both in its low degree of hardness, its texture, and in having fine specks of pyrites and of a black metallic-looking mineral scattered through it. . . . . Sometimes, as in the Australia workings, both varieties of rock are met with in the same mine."

A preliminary report on the specimens now described has been made by the Author† in connection, in which the following conclusions are arrived at—

"The country rock is generally soft, of a green colour, and has a schistose structure, which sometimes occasions a considerable amount of fissility. The divisional planes exhibit a silvery sheen, due to the development of secondary mica.

"That this rock is of igneous origin is evident from its mineralogical constitution and structure. Quartz, felspar, ilmenite, and magnetite are among the original constituents, and that characteristically igneous structure, the micro-pegmatitic, so common among the acid eruptives, is sometimes well shown (*e.g.*, the Australia and Ivanhoe country rocks). The green colouration is due to chlorite, which acts as a pigment when finely disseminated as it generally is."

* *Op. cit.* p. 310.
† Ann. Rept. Dept. Mines and Agric. N. S. Wales for 1897 [1898], p. 192.

"1. The country rock on the hanging and footwall sides of the deposit is one and the same.

"2. The country rock is of igneous origin and belongs to the acid group; in all probability it is a quartz-felspar porphyry, but may approximate to a granite in places.

"3. The country rock has undergone great alteration, both chemical and mechanical. It would appear probable that deep-seated alteration occurred prior to the lateral crushing that imparted to the rock its fissility and schistose structure. Subsequently, solutions containing metallic salts, silica, carbonates of lime and magnesia, and possibly alumina, permeated the rocks, depositing their contents in the spaces resulting from the crushing just referred to and by pseudomorphous replacement.

"4. The "lodes" represent belts along which the crushing effects have been most severe, and the deposition of secondary material more abundant. They are, in fact, more highly altered portions of the country rock."

While there is thus a general consensus of opinion that the Kalgoorlie deposits occur in an area of very ancient igneous rocks that have been rendered more or less fissile by pressure, there is considerable difference of opinion as to the exact nature of the country rock. While there is a tendency to fall back upon that talismanic word "diorite," it does not appear that recourse has been had to the microscope to any extent. There can be no doubt that diorite dykes exist, and one such will be referred to in the course of this paper; but it would appear as if every green rock not showing readily recognisable macroscopic characters has been set down as diorite. In the succeeding pages of this paper abundant evidence will be brought forward that, whatever the true country-rock may be, it is not a diorite. To the Australian miner "diorite" is a word to conjure with; this probably arising from the fact that gold reefs, in the Southern Hemisphere at any rate, are very commonly associated with diorite dykes. When a property is to be placed on the market it is especially desirable to find diorite, and there is no rock from a sandstone to a granite that the Writer has not at some time or other heard classed as such.

Description of the Specimens.—The specimens now under description come from the following mines:—

Boulder Perseverance,
Great Boulder,
Boulder Junction,
Boulder Main Reef,
Lake View,
Lake View Consols,
Lake View and Boulder Junction,
Australia,
Australia East Lease,
Kalgurli.

As mentioned by Mr. Frecheville, these comprise two varieties—to the unaided eye, that is. Under the microscope these are seen to be one and the same rock, the difference being one of colour only, due to the proportion of chlorite present as a pigment. The distinction between light green and bluish green varieties, drawn by Mr. Bancroft, is not exemplified by this set of specimens. While the actual lodestuff has a decided schistosity, this would not appear to be the case with the country rock, even in the immediate vicinity of the lodes; and, while in the descriptions below a tendency to schistosity will generally be noted, there are cases where it is entirely absent. As the microscope evidence points to the practical identity of the whole series, it will be well, before describing them in detail, to avoid repetition by summarising the characters of the constituent minerals. The recognisable minerals present are *quartz* (primary and secondary), *felspar* (*orthoclase* and *plagioclase*), *titaniferous iron ore* (with *leucoxene*), *magnetite*, *pyrites*, *carbonates* (*calcite*, *&c.*), *apatite*, *chlorite*, and *sericite*. Of these *quartz*, *felspar*, *ilmenite*, *magnetite*, and *apatite* may be regarded as primary.

Quartz is almost invariably present. With one possible exception it is never idiomorphic. It occurs in groups of irregular grains which generally extinguish simultaneously between crossed nicols. These grains vary in size down to the very smallest particles. There can be no doubt that these groups of quartz-grains in optical continuity with one another represent individuals that have been split up into isolated portions. They may be conveniently compared to archipelagoes of islets. In connection with these archipelagoes the following points may be noted:—

(*a*) Every gradation can be traced from the origination of cracks traversing the quartz, through gradually widening channels of separating matrix, to minute widely-separated grains which finally disappear altogether.

(*b*) The members of each archipelago extinguish together: occasionally strain-shadows may be noticed, or—rarely—dislocation has taken place.

(*c*) Transparent colourless rods are frequently present as inclusions. These may sometimes be seen traversing two or more separated grains and in some cases the interstitial material also.

(*d*) Bands of inclusions can sometimes be traced into successive grains like the rods in *c*.

It must be pointed out that this invasion and absorption of the quartz in no way resembles the corrosive action of a molten magma. In this paper no attempt will be made to deal with the processes by which the absorption is effected. The change would appear to be initiated along cracks. The replacing material is frequently calcite. It may be that the process is to some extent one of pseudomorphous replacement. The transparent rods have a slight tendency to cluster

near the margin of the grains. Their continuation beyond the limits now occupied by the containing quartz is evidence of the former extension of the latter. The effect of pressure in bending one of these rods is sometimes seen.

Secondary quartz is sometimes present.

Felspar—It is only occasionally that felspar substance can be detected in a condition in which it can be identified with certainty, but the appearance of whitish patches with rectilinear outlines on a cut surface is often very suggestive of its former presence. The change undergone has been principally the development of sericitic mica. Both orthoclase and plagioclase occur. The felspar is occasionally associated with areas of micropegmatite.

Titaniferous Iron Ore—As constantly present as the quartz in both country rock and lodestuff. It is sometimes associated with crystallised magnetite, and, in the lodestuff, with secondary pyrites. It occurs in grains of most irregular outline, and sometimes in such abundance as to give a spotted appearance to hand specimens of the rock. Alteration is always in evidence. Sometimes this consists in the characteristic development of leucoxene; but frequently the change has been more thorough, and the whole crystal pseudomorphously replaced by an opaque yellowish product. There is, perhaps, a tendency to granulation as the ore-body is approached.

Magnetite—Not of such common occurrence as the titaniferous iron ore. It occurs in little octahedral crystals, and its presence can frequently be detected as magnetic particles in the crushed rock. Both it and the titaniferous iron ore sometimes occur as microscopic dust and act as a pigment.

Apatite—Occasionally occurs as small grains in the matrix.

Sericitic Mica—Always present. The vividly polarizing little rods of the substance have a criss-cross arrangement when the rock is not schistose; in the latter case they are foliated, thereby causing the schistosity. It would appear as if prolonged deep-seated alteration preceded the foliation—and consequently the mineralisation—of the ore-bodies.

Chlorite—This is not such an important constituent as the deep green colouration would often suggest. It is generally scaly, and may be regarded as a pigment: when absent the rocks are light-coloured. It is sometimes evidently just as much a secondary product as the carbonates and pyrites; alumina has, in fact, been detected in the mine waters (p. 36).

Carbonates—The powder on a cut surface of most of the specimens effervesces more or less freely when treated with dilute acid. Under the microscope they appear either in distinct crystalline areas or scattered promiscuously over the slide as an ill-defined cloudy product. The presence of carbonate of magnesia is shown

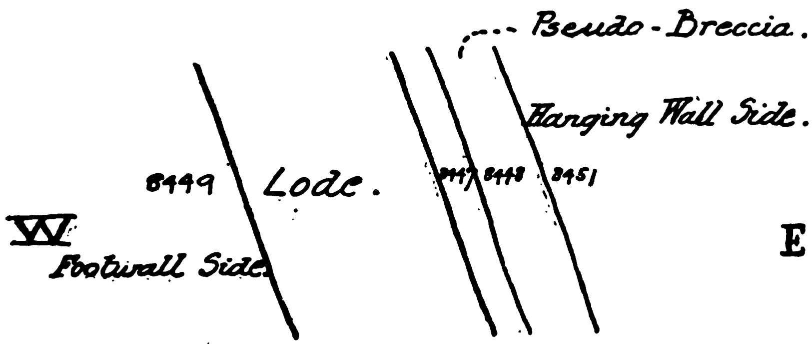
by analysis, and sometimes also by the acid having little when cold. Calcite is an important gangue material in the lodestuff, sometimes occurring in large masses with calaverite (Block 14). Quartz is frequently replaced by calcite.

Pyrites—A common constituent of the lodestuff, and to a much less extent of the rock in its vicinity.

In one or two of the slides a strongly pleochroic brown mineral, possibly with straight extinctions, is very sparingly present.

Boulder Main Reef.

Specimens 8447, 8448, 8449, 8451,* are from the near neighbourhood of one nother as shown:—



8451. Country rock on the hanging-wall side—A greenish, roughly schistose, felsitic-looking rock; specific gravity 2·9. Magnetite can be seen in small octahedral crystals. Cut surfaces are very calcareous, show leucoxene pseudomorphs, and have a mottled green and white appearance. Under the microscope quartz is plentiful in grains of considerable size; they are evidently the remnants of much larger individuals, as described above (Plate I, Fig. 1). A good instance is afforded of transparent rods traversing several fragments of quartz and also the interstitial material. Although these rods would appear to have been dislocated to some extent, the quartz grains they traverse show no signs of optical strain. There is an exception to this, however, in the case of one group of fragments, a member of which has a different optical orientation to the rest of the group. The iron ores are sometimes intimately associated with one another. The titaniferous iron ore is very irregular in outline (Plate I, Fig. 2), being deeply indented by inlets of matrix. Magnetite is occasionally included in the quartz. Chlorite is not abundant, and occurs in more or less well-defined areas. Here and there are small patches of micropegmatite. The matrix consists largely of an aggregation of transparent little crystalline rods and imbricating scales; these show vivid colours between crossed nicols and generally have a criss-cross arrangement, but are sometimes well drawn out.

* These numbers are those under which the rock specimens are registered at the Mining Museum, Sydney.

8448. From a depth of one hundred and seventy feet, next the hanging-wall. Specific gravity, 3. A soft dark-green rock with white areas, giving it an appearance of brecciation. Crystals of titaniferous iron ore and magnetite are conspicuous, and in some respects the rock is not unlike a chlorite schist. Calcite is abundant in the light areas. Under the microscope the mottled green and white appearance is seen to be due to the irregular distribution of chlorite, bright green scales of which mineral occupy a considerable proportion of the rock. A little quartz is present showing a zone of interaction between it and the matrix. The base consists principally of scales of chlorite and water-clear granules, but here and there the vividly-polarizing rods are seen.

8447 (Plate II, Fig. 2). From the hanging wall. A very pyritous roughly-schistose rock; specific gravity, 3·14. The divisional planes are coated with sericitic mica, a silvery-green appearance being thereby imparted to the rock. Strong effervescence follows the application of weak acid to a cut surface, calcite being abundantly present both in veins and generally distributed throughout the rock. Under the microscope some titaniferous iron ore in small grains and much pyrites are detected. The pyrites occurs as small grains and crystals arranged in bands or patches, or scattered through the rock. Calcite is abundant. Quartz occurs in very small fragments only: secondary silica is also present. The general appearance of the slide is that impressed upon it by the predominating carbonate grains and streaks of sericite. Some of the quartz and calcite occurs as lenticles following the general trend of the sericitic bands, which direction is also often followed by the bands of pyrites. This is best shown when calcite is less abundant, in which case something approximating to a mylonitic structure appears, portions of the ground mass occupying the face between the sericite fibres, and presenting a mosaic-like appearance. It would appear as if lines of shearing were thus indicated along which the quartz has been rendered lenticular or even passed into a mosaic.

8449. From the footwall at a depth of one hundred and seventy feet. A greenish pyritous rock; specific gravity, 2·9. There is a slight tendency to schistosity and a general felsitic aspect. The abundant presence of carbonates is indicated by copious effervescence all over a cut surface when treated with weak acid. Magnetite can be readily picked out from the pulverised stone. Under the microscope, by reflected light, certain conspicuous opaque white patches, irregular, but with a tendency to rectilinear outlines, may possibly represent felspar. Iron-ores are represented by titaniferous iron, with characteristic leucoxene alteration, and a mineral like magnetite, but with an irregular marginal zone of opaque white material which may be, perhaps, classed as titano-ferrite. Quartz has formerly occupied large areas, but absorption has been so effective that these are now, for the most part, represented by small fragments widely separated by interstitial

matter. The quartz has been squeezed (without shattering) to some extent, and strain-shadow phenomena are occasionally present. The component fragments of these quartz groups are sometimes separated by tongues of calcite, and rod-like inclusions may be seen continued across successive grains.

In places the residual quartz grains have an appearance bearing some resemblance to micropegmatitic structure, and the possibility is suggested that this structure, as exhibited by the quartz in an altered rock, may sometimes be of secondary origin. Scaly chlorite is present, principally aggregated in the dusky patches already referred to.

The ground mass is in part calcareous, but very much of it consists of colourless vividly polarising scales and granules, while wisps of sericite wind round the quartz fragments or are drawn out into lines.

8450. Country rock. A chloritic, pyritous rock with a specific gravity of 2·9. Magnetite and leucoxene are well-shown on cut surfaces, and vigorous effervescence follows the application of weak acid to the latter. Under the microscope magnetite is seen as small crystals. Titaniferous iron ore sometimes occurs in linearly-disposed bars. Chlorite is very abundant. The slide shows a large patch of micropegmatite with an approximation to centric structure, a portion of which is traversed by transparent rods.

A comparison between these specimens taken from different portions of the mine brings out the following points:—

1. The similarity between the hanging and footwall country proves the rock on either side of the lode to be identical. The deposit is not, therefore, likely to be a contact one, and it will be difficult to prove whether faulting has taken place or not.
2. Alteration would appear to become more intense as the ore-body is approached. Generalisation is unreliable when based upon the examination of so small a number of specimens, yet it would seem as if the hanging-wall rock were more schistose and more calcareous than that in its vicinity further from the lode, and, further, as the ore-body is approached, the quartz shows a tendency to become scattered and finely-divided, and is, perhaps, replaced to some extent by lenticles of mosaic.

Great Boulder Mine.

8444. Country rock from the footwall. An olive-green, schistose, pyritous and calcareous rock, traversed by a calcite vein; specific gravity, 2·89. In appearance the rock approximates to a chlorite schist. Abundant leucoxene pseudomorphs are visible on cut surfaces. A special examination was made of this rock with a

view to ascertaining the nature of the carbonates. A piece free from calcite veins was crushed and treated with warm citric acid. Considerable effervescence ensued indicating the general presence of carbonate of lime. Subsequent treatment with cold hydrochloric acid occasioned slight effervescence, which became brisk on warming. Carbonate of magnesia is probably present, as well as carbonate of lime. A few grains of magnetite are visible. Splitting can, to some extent, be effected along planes coated with silvery mica. Under the microscope chlorite is seen to be in much less quantity than one would be led to expect from the colour of the rock. The areas of residual quartz are generally small, but widely separated pieces may sometimes be seen extinguishing together. The existence of strain in the quartz is indicated by irregular extinction and, perhaps, by lines of inclusions. Blade or rod-like inclusions traverse the quartz as usual. With high powers the base can be resolved into a complex of chloritic scales and colourless microlites of white mica; these latter are sometimes arranged in lines, giving rise to a general streakiness.

8443. Country rock from the hanging wall.—A greenish, schistose, calcareous rock, very similar in appearance to 8444; specific gravity, 2·84. A cut surface shows very numerous small pseudomorphs of leucoxene and some pyrites. The general appearance of the rock when broken across the planes of schistosity is that of a porphyroid. Under the microscope, as the schistose structure and the sheen of the rock would lead one to expect, there is a great development of white mica. Showing vivid interference colours, the mica can be seen in shreds occupying large areas, or sweeping round and past the other constituents. With high powers it may be resolved into minute crystals, among which are scattered colourless needles of other minerals. Chlorite is, in places, spread over such areas of white mica in the form of scales, and acts as a pigment. It is not abundant, and sometimes lies along the foliation planes. Granular aggregations of calcite are common. Lying in this ground mass of colourless mica, cloudy carbonates and green chlorite, are very numerous small fragments of titaniferous iron ore and quartz. The former is entirely replaced by dirty-white alteration products, while the quartz is evidently in a very advanced stage of absorption. One of the larger fragments of quartz is seen shedding its outer portions in successive coats through the introduction of chloritic and other material. That the quartz fragments belong to individuals formerly much larger is evidenced by the presence of outlying grains, sometimes barely discernible, in optical continuity with them, but separated by calcite, mica, &c. Other fragments are seen surrounded by a clear area giving mottled-grey effects between crossed nicols, and resolvable with high powers into a structureless base containing numerous colourless plates and rods with shreds of white mica. Similar areas in which quartz is not now visible may indicate its total absorption and disappearance. Quartz fragments are sometimes intruded by tongues of calcite.

8513. Ore from winze, below two hundred foot-level.—This is similar in appearance to the country rock just described; but a much larger quantity of pyrites, in the form of very minute cubes, is present. A cut surface shows areas of white calcite, and is traversed by minute faults. Under the microscope it is seen to consist principally of calcite, chlorite, and pyrites. Quartz is even now conspicuous, and would appear to have been abundant once, as the grains are much shrunken and lie in a granular aggregate of clear anisotropic particles with calcite. In other cases such aggregates exist by themselves, the quartz being entirely gone.

8436. Ore.—This is pyritous, and has a spotted appearance due to iron-ores and blebs of quartz; specific gravity, 2·91. Under the microscope quartz is abundant, occurring in blebs of considerable size. The quartz occasionally shows what appears to be crystallographic outline, and may perhaps be secondary. As before outlying islets, in optical continuity with the main mass, point to the original greater extension of the individuals. This is further proved by the irregularity in the outline of the grains, by the continuation of inclusions and lines of inclusions into the matrix, and by the appearance of the contact zone. Occasionally complete replacement by mosaic has taken place. The operations involved are seen to consist, in part, of the extension from the quartz into the peripheral region of colourless blade-like and acicular crystals, little plates, &c., and gradations can be traced to areas still behaving as quartz between crossed nicols, and yet almost entirely occupied by such aggregates. "Strain-shadow" phenomena are practically absent, but the larger individuals of quartz are sometimes traversed by lines of inclusions. The ground mass consists largely of calcite and shreds of vividly-polarising white mica with chlorite, imbedded in which are, in addition to the quartz, grains of magnetite and leucoxene pseudomorphs.

8435. Another specimen of pyritous lode-stuff, possessing a rough schistosity; specific gravity, 2·85. This must represent an advanced stage in alteration. A very thin section is perfectly transparent, and shows the rock to consist of more or less foliated white mica and chlorite with calcite, quartz, and iron-ores. Quartz now occurs only as very small grains, the former greater extension of which is indicated by the irregularly-polarising areas adjacent to them. Calcite occurs in definitely-bounded plates. The white mica is largely drawn out linearly, thereby imparting to the rock its fissility; it also occurs in criss-cross fashion.

8467. Telluride-ore from the Boulder Perseverance—A slide from this showed large individuals of titaniferous iron ore with characteristic leucoxene, magnetite, and pyrites. Quartz is seen in various stages of obliteration. The opacity of the slice is against much detail being made out in the ground mass, but it is largely composed of calcareous material and colourless scales, rods, &c., variously aggregated.

Kalgurli.

8459. Country rock—A dark-green, somewhat felsitic-looking rock, containing the needle variety of arsenical pyrites; specific gravity, 2·94. Under the microscope iron ores are seen to be abundant, seattered in a granular condition through the slice. Magnetite is in distinct crystals, and titaniferous iron ore is in an advanced stage of alteration. The spaces occasioned by the irregular outline of the latter are occupied principally by chlorite. Pyrites is not very abundant. The evidence afforded by this rock is of special importance from the presence, suspected in some of the rocks described above but here beyond doubt, of felspar. It is generally very much altered, more especially in the direction of replacement by calcite, but simple and multiple twinning, and occasionally crystallographic outlines, are distinct enough. The felspar does not appear to have undergone crushing, but has sometimes been broken up into isolated portions by a process of absorption similar to that so often referred to already in this paper as being characteristic of the primary quartz in all the specimens now being described. Quartz occurs in small fragments, neighbouring pieces sometimes indicating by their simultaneous extinction their community of origin. The ground mass consists of scaly chlorite, calcareous material, and colourless spots, rods, and rhomboidal plates; it would seem as if these latter were in part calcite set in a clear structureless base. Veins of calcite and of secondary quartz are present. The quartz is to some extent traversed by highly-refracting rods which may, perhaps, be rutile, although not forming a sagenite web.

8457. Another specimen of country rock very similar in appearance to the foregoing; specific gravity, 2·98. A cut surface shows numerous opaque white spots, imparting to it a mottled appearance. These latter sometimes have rectilinear outlines and are suggestive of felspar. Pyrites is present in veins and specks, and the rock is calcareous—more especially the white spots. Much magnetic iron-ore is present. Under the microscope quartz is seen in very distinct grains, which are often much elongated in form, but not lenticular. It generally occurs in groups, the individuals of which extinguish sharply together with the barest possible indication of strain phenomena. The section is traversed by dusky lines (shearing ?) to which the quartz fragments show a tendency to conform in the orientation of their longer axes. The invasion of quartz by sericite and calcite is well shown. Where not obscured by calcareous material the base is seen to consist very largely of minute vividly-polarising rods of sericite, frequently arranged in criss-cross fashion, but sometimes drawn out in one direction, with water-clear interstitial matter. These clear areas are frequently approximately rectilinear and are to some extent outlined by chlorite; they may represent felspar. Scaly chlorite is disseminated through the rock.

8509. Typical ore, occurring in stringers traversing the country—The specimens hitherto described have been dark in colour, but this, together with some from the Australia East Lease, are very much lighter. It is grey in colour, with a somewhat

trachytic appearance and a slight tendency to fissility. The divisional planes are conspicuously sericitic. It is abundantly speckled with titaniferous iron-ore and magnetite, and a slight effervescence is noticeable on a cut surface when treated with acid. Close inspection reveals the presence of limpid grains of quartz in abundance. The rock shows a little pyrites and weathers a deep red-brown colour. Under the microscope it is seen that the difference in appearance is one mainly of colour, consequent upon the entire absence of chlorite. There are the same archipelagoes of optically-continuous quartz traversed by transparent rods. Vividly-polarising sericite is abundant. It is generally arranged in one direction, but sometimes lies criss-cross. Much of the quartz is seen to be almost entirely replaced by such sericite. Carbonates are abundant.

8455. From a telluride vein (Pl. II, Fig. 3, and Pl. III, Fig. 2)—This specimen shows on one side a vein of quartz, about four millimetres thick, bounded on either side by, and to some extent containing, a brassy-looking telluride of gold (calaverite) closely resembling pyrites. The telluride also invades the rock for a distance of about a centimetre, staining it the chocolate tint that appears to be characteristic of the weathering of telluride ores. The rock is dark-green in colour, speckled with small crystals of magnetite, and shows leucoxene pseudomorphs abundantly on a cut surface; specific gravity, 3. Under the microscope chlorite and carbonates are seen to occur in great abundance, constituting a base in which are set the iron-ores and residual quartz-grains of the usual character. To investigate the nature of the carbonates the cover-glasses were removed from some of the slides. Very dilute hydrochloric acid gave rise to copious effervescence. When this had subsided very little additional effect was produced by concentrated acid—hot or cold. It thus appears that the bulk of the carbonates are lime rather than magnesia. Naturally, the removal of the carbonates brings the chlorite into greater prominence.

Lake View Consols.

8460. Lode-stuff—A pyritous, calcareous, light-coloured rock, with a slight greenish tinge in places; specific gravity, 2·9. It is distinctly fissile, showing sericite. Under the microscope the highly altered condition of the rock is apparent. There is little, if any, chlorite, but a great development of sericite, to the disposition of which in interlacing bands the fissility of the rock is due. A little of the sericite, however, shows the criss-cross structure. The pyrites granules are similarly arranged. Calcite is very abundant, in distinctly crystalline patches. Quartz occurs, the grains sometimes showing the usual simultaneous extinction and transparent rods. A vein of secondary silica traverses the section.

8461. Ore (assaying ten ounces of gold per ton) from the three hundred-foot level. A greenish rock of felsitic appearance, with pronounced schistosity and development of sericite; specific gravity, 2·86. The rock is pyritous and effervesces slightly in acid. Under the microscope it is seen to be highly silicified, being

traversed by a network of interlacing areas of secondary quartz. Primary quartz can be recognised by the presence of the included transparent rods so frequently referred to before.

Lake View.

8515. Country rock from cross-cut at the one hundred-foot level—A soft olive-green rock, spotted with titaniferous iron ore; it is highly calcareous being traversed by veins of calcite. Under the microscope, titaniferous iron ore is seen in comparatively large and exceedingly irregular masses with characteristic leucoxene alteration. Quartz likewise occurs in large masses; the splitting up of the original individuals not having gone so far as in most of the rocks hitherto described, the fragments are larger, and sometimes separated from one another by cracks only. This severance can be traced in every stage from incipient cracks, which, by their widening and infilling with calcite and other material, lead to the isolation of portions of the quartz. The enlargement of the channels so formed leads to the formation of the archipelagoes of quartz fragments. Inclusions are not very plentiful in the quartz; when present they generally consist of transparent rods, and these are commonly found near the margin. These rods are occasionally seen in cross-section; the outline being hexagonal. There is but very slight indication of straining. This slide shows what must, I think, be taken as true micro pegmatitic structure. The hesitation in definitely determining it as such, arises from the possibility that a secondary structure simulating the micropegmatitic may arise in an altered rock from the absorption of quartz in a regular manner. Chlorite occurs, as veins principally, but not in large quantity. The original presence of felspar is almost certainly indicated by light coloured areas, rectilinear in outline and mainly occupied by sericitic matter lying criss-cross. Dusky lines cross the slide in various directions, sometimes crossing the quartz as veins filled with chlorite; these might be taken for lines of shearing, were there any evidence of dislocation.

Lake View and Boulder Junction.

8462. Country rock—This specimen differs in some respects from any of the others now being described. It is a felsitic-looking rock, greenish in colour, strongly calcareous and slightly pyritous, having only a slight tendency to schistosity; specific gravity, 2·7. Under the microscope it presents a homogeneous structure, consisting of a felsitic base in which are embedded portions of phenocrysts of felspar—principally orthoclase. These are highly altered, but still show in places interference effects between crossed nicols and twinning. In addition there are small fragments of apatite, magnetite, and titaniferous iron ore, a little chlorite and other green products, together with a strongly pleochroic mineral, almost devoid of structure, but apparently possessing straight extinctions. This rock certainly has the appearance of an altered felspar porphyry.

From this mine there is also a specimen of carbonaceous slate with secondary pyrites.

Ivanhoe.

8472. Country rock from a depth of three hundred feet. A greenish, calcareous, felsitic-looking rock; specific gravity 2·876. Titaniferous iron ore and quartz are visible. Under the microscope titaniferous iron ore is seen in large extremely irregular crystals with characteristic leucoxene. Magnetite dust occurs. Quartz is in fragments of fair size, in various stages of absorption and replacement, more particularly by calcite. It occasionally affords direct evidence of crushing, as it is sometimes shattered with break of optical continuity. The evidence given by this rock is increased in importance by the presence of felspar—highly altered in all cases, yet, occasionally showing colouration between crossed nicols. Excellent micropegmatitic structure is also present. It is well-shown surrounding a dusky rectilinear area, probably representing a pseudomorphous replacement by calcareous material, and, perhaps, even better round a piece of crushed quartz. Micropegmatite occupies a considerable portion of the sections.

8514. Country rock from the west cross-cut at the one hundred foot-level, two hundred feet west of the middle vein.—A dark-green, homogeneous rock, showing titaniferous iron ore and quartz, and closely resembling a quartz-felsite in appearance. Effervescence takes place strongly on a cut surface; but it is confined to certain light-coloured rectilinear areas. Under the microscope titaniferous iron ore, (with leucoxene), magnetite and quartz are seen lying in a calcareous matrix. The quartz is sometimes shattered, and exhibits strain-shadows to some extent. Micropegmatite (Plate II, Fig. 1) is present. Light-coloured areas, with a tendency to rectilinear outlines, now occupied by rods of sericite lying criss-cross in a clear feebly polarising matrix, probably represent felspar.

8471. Lode-stuff.—Pyritous, and very calcareous, with a tendency to fissility; specific gravity, 3·1. Under the microscope titaniferous iron ore is seen to be abundant, but occurs in grains of small size only. Some magnetite is present. Pyrites occur in small crystals, generally disseminated or arranged along definite lines. Calcite is abundant in well-defined crystals. Quartz, both primary and secondary, is plentiful. Primary quartz is an important constituent. It occurs in large fragments, and constitutes a very considerable proportion of the section. It possesses the usual characteristics. Acicular or rod-like inclusions are conspicuous, one or two of them being coloured but not sensibly pleochroic. The secondary silica has been introduced, at any rate to some extent, subsequently to the calcite.

Australia Mine.

8433. Rock from the Dam.—Dull-green in colour, calcareous, and slightly pyritous, with some tendency to fissility; specific gravity, 2·9. A cut surface shows numerous crystals of titaniferous iron ore (with leucoxene), abundant rectilinear opaque areas that effervesce vigorously when treated with acid, and blebs of

quartz. Under the microscope, quartz occurs in grains of considerable size showing the usual characters. Rod-like inclusions are common, often being continued into the environing material. It sometimes affords evidence of shattering. With the quartz are associated areas of micro-pegmatite. Veins of secondary quartz are also present. Chlorite is generally distributed, but not so abundant as might have been expected from the colour of the rock. As in other cases, although the extreme alteration prevents a definite determination being arrived at, the appearance of the opaque white areas is suggestive of felspar. In areas not obscured by granules of dusky carbonates are sericite rods lying criss-cross.

8424. Lodestuff from the two hundred and twenty-five foot-level.—A green felsitic-looking pyritous sericite rock, with a tendency to schistosity; specific gravity, 2·85. Quartz blebs can be readily distinguished with a lens. Under the microscope there is abundant evidence of silicification in the form of veins of secondary quartz. Bands of sericite give rise to foliation. Pyrites is very closely associated with the titaniferous iron ore. Calcite is present in large masses not generally disseminated. The primary quartz shows strain-shadows, and sometimes occurs in archipelagoes. It is frequently difficult to say whether we are dealing with crushed primary quartz or secondary silica.

Australia East Lease.

8511. Country rock from a cross-cut in the one hundred foot-level.—A flesh-coloured homogeneous rock, veined by quartz, and calcareous throughout. Owing to its opacity but little can be made out under the microscope. Minute sericite rods can, however, be distinguished on the edges.

8510. Another specimen of country rock from the same cross-cut as 8511. A soft rock with a pale-greenish tinge, with a tendency to fissility, and a general sericitic appearance. It is pyritous, is attacked strongly in places by acid, and is traversed by quartz veins. It seems probable that the preceding rock, 8511, is similar to this but more altered by secondary minerals. Titaniferous iron ore is present in rather small grains sometimes showing, by reason of the disposition of leucoxene, a concretionary appearance. Pyrites is sometimes intimately associated with it. The base consists of foliated sericite with cloudy opaque-white structureless material, probably calcareous. Calcite sometimes occurs in crystalline plates. No chlorite is present. Quartz also is entirely absent, but there are somewhat lenticular clear areas, showing a fine mosaic between crossed nicols, that may represent that mineral.

8508. Country rock from the hundred and forty foot-level—(Plate III, Fig. 1). The rock is flesh-coloured, pyritous, and conspicuously spotted with iron ores. It is fairly hard and shows a general effervescence when treated with dilute

acid. A calcareous vein traverses the rock. With a lens blebs of quartz may be seen, and the whole has a felspathic appearance. Under the microscope the great importance of this specimen becomes evident, as it may give the clue to the interpretation of all the others. Although highly altered it is a quartz-orthoclase-plagioclase rock with a granitic structure, and would be termed granitite by some petrologists. The readily recognisable minerals present are *quartz*, *orthoclase*, *plagioclase*, *magnetite*, *titaniferous iron-ore*, *calcite*, and *sericitic mica*.

Quartz—This is not so abundant as the felspar and occurs in small grains only. These grains are sometimes cracked, showing optical discontinuity, and occasionally show strain-shadows. A portion of the quartz may be secondary. Occasionally may be seen the commencement of the process of absorption and isolation of portions which eventually gives rise to the archipelagoes of grains in optical continuity so often referred to above. Most of the grains contain one or more transparent rods.

Felspar—The most important constituent. Although much altered the optical characteristics of the mineral between crossed nicols are readily recognised. Both simple and multiple twinning occur. An instance is afforded of bending with extreme alteration of the felspar substance in the neighbourhood of the fold. Alteration consists principally in the development of sericite and the appearance of calcite. Sericite not only occurs in the felspars but also in some abundance in wavy bands wrapping round or cutting across the felspars.

Titaniferous iron ore occurs somewhat sparingly as opaque yellowish-white alteration products.

8512. Country rock from the hundred and forty foot-level, west lode.—A soft schistose sericitic rock. Under the microscope it exhibits a pronounced schistose structure by reason of the foliation of the abundant white mica. Quartz occurs in archipelagoes and in single grains round which the white mica is wrapped. The quartz sometimes shows strain-shadows, or peripheral granulation and tailing out due to crushing. A reddish-brown highly pleochroic mineral with irregular outline, and yet perhaps showing straight extinctions occurs; it may perhaps be tourmaline. This rock shows cataclastic structures better than any of the other specimens.

8458. From a dyke traversing North Kalgoorli and traceable for a very considerable distance. This is totally different from any of the rocks now being described. It is dark-green and opaque-white mottled rock, with a specific gravity of 3. No metallic minerals are visible in it. Under the microscope it is seen to consist principally of pale actinolitic hornblende, with very dusky felspar, quartz, and some apatite. In its present condition it is undoubtedly almost entirely

reconstructed, and may be term an amphibolite. To some extent the hornblende shows nuclei of a brown striated slightly pleochroic mineral. This would appear to be diallagic in character, and from it the hornblende has probably been formed. As this rock has no connection with the ore deposits, it is not necessary to consider it further in this place.

Before proceeding to consider the significance of the evidence detailed above, the facts presented by chemical analysis may be referred to.

An analysis of an average sample, representing one hundred tons of Great Boulder ore, is reported by Mr. Skewes. *

Silica		48·43
Iron		10·24
Alumina		1·98
Lime		9·86
Magnesia		2·03
Sulphur		3·66
Copper		0·33
Carbonic dioxide		7·75
Oxygen		3·05
Alkalies, &c.		12·65
		99·98
Insoluble		64·00
Soluble	Metallic iron	6·64
	Sulphur	5·94
	Carbonate of lime	14·01
	Carbonate of magnesia	9·66
		100·25

No doubt titanium was undetermined, and is included with the "&c." The high percentage of carbonate of magnesia will be noted.

Mr. Skewes proceeds to quote an analysis of mine water by Mr. Bowen Jenkins.

Chlorides of magnesium and sodium	6·95
Carbonate of lime	0·86
Alumina and oxide of iron	0·49
Sulphur	0·12
Total solid matter	8·42

The water is denser nearer the mineral belt, and that issuing from the borehole is almost milky white.

* Mining Journal, 1898, LXVIII, No. 3264, p. 312.

Mr. Frecheville quotes * the following analyses, made by Dr. Helms, of Sydney, of a characteristic specimen of Great Boulder ore (a non-quartzose variety), and of country rock from the vicinity of the ore (the winze below the two hundred-foot level.

		Ore.	Rock.
Sulphur		5·49	0·22
Carbonic acid		8·38	11·73
Titanic acid (TiO_2)		2·57	0·71
Soda (Na_2O)		2·93	2·46
Potash (K_2O)		2·25	2·94
Soluble	Oxide of iron	17·84	9·69
Soluble	Iron as pyrites (calculated from the sulphur as FeS_2)	4·80	0·19
Soluble	Alumina	6·62	4·62
Soluble	Lime	4·77	8·20
Soluble	Magnesia	4·87	5·35
Soluble	Copper	0·14	0·05
Soluble	Manganous oxide	traces	traces
Soluble	Silica	0·21	0·28
Insoluble	Silica	34·83	42·48
Insoluble	Ferric oxide	1·14	1·26
Insoluble	Alumina	3·05	9·29
Insoluble	Magnesia	0·10	0·24
		99·99	99·71

Dr. Helms remarks that the lime and magnesia found in the soluble portion would require 9·08 per cent. carbonic acid for the ore, and 12·32 per cent. for the rock, so that a small part of them must be in combination with silica.

Mr. Claudet † quotes an analysis of ore (mine not stated) as follows:—

Peroxide of iron	15·45
Oxide of manganese	0·18
Copper	0·05
Sulphur	0·12
Lime	0·20
Alumina	1·66
* Siliceous rock	77·93
Combined water and loss	4·41
	100·00

* Silica	56·60
Alumina	16·92
Lime	0·30
Magnesia	0·25
Alkalis, chiefly potash	3·66
Loss	0·20
	77·93

Mr. Claudet notes that the siliceous rock is apparently decomposed felspathic rock.

In the discussion on the paper, several of the speakers referred to the continual presence of magnesia, in some cases amounting to 1½ per cent.

* *Op. cit.*, p. 310.

† Notes on the Experimental Treatment of a Gold Ore from the Hannan' District, Coolgardie, Western Australia Trans. Inst. Mining and Metall., (1897) V, pp. 327-330.

A consideration of these analyses suggests the following points:—

1. As noted by Dr. Helms, there is not enough carbonic acid to satisfy the lime and magnesia; consequently, a certain proportion of these must exist as silicate, *i.e.*, in all probability in combination with other compounds, to form the constituent minerals of crystalline rocks. Microscopical examinations (specimens 8443, 8444, 8513, pp. 27, 28, 29) has already revealed the presence of such minerals.

2. The presence of soda may be regarded as pointing to the existence of soda-felspar substance.

3. Neglecting all the carbonic acid and soluble portion, the percentage composition of the remainder stands as follows:—

Titanic acid	1·19
Soda	4·13
Potash	4·93
Silica	71·31
Ferric oxide	2·11
Alumina	15·76
Magnesia	0·42
	99·85

This agrees very closely with the typical composition of an acid eruptive. Of course very little stress can be laid on such a computation: a portion of the magnesia, now soluble in acid as carbonate, for instance, may very reasonably be regarded as having been derived from the decomposition of ferro-magnesian silicates in the original rock; further, some magnesia is required by the chlorite. The aggregate percentage of lime and magnesia (in the rock analysis) is 13·79. If 7 per cent. be regarded as the percentage derived from the decomposition of rock-forming minerals in the original rock, the silica percentage falls to 66·74, which might well be that of a granitite.

Conclusions.

It now remains to consider the bearing of the microscopic and chemical evidence thus given. The specimens described have been collected from varying levels and different mines on the Kalgoorlie Field; they comprise also samples of both ore and country rock. The general appearance, and particularly the results obtained by the examination of thin sections under the microscope indubitably prove the following points, viz.:—

1. The country rock is the same throughout the field; broadly speaking, the description of one would apply to another. They all agree in containing titaniferous iron ore, quartz, and white mica.

2. The ore-bodies are simply more highly altered country rock. It will be noted that the titaniferous iron ore and primary quartz occur in the ore, as in the country, with a tendency however to granulation.

3. The rock is of igneous origin, and in all probability, of great geological antiquity. The pegmatic structure and mineralogical constitution leave no doubt as to the origin; and the extreme alteration, of a deep-seated character, proves the antiquity. Titaniferous iron ore is thus found (8433, Great Boulder Mine) completely converted into opaque yellowish-white products; very much of the original silicates has been replaced by sericitic material, and the primary quartz has been split up into groups of fragments, or completely absorbed.

4. The country rock affords but very little indication of shattering or crushing; the alteration it has undergone has been chemical rather than cataclastic,—effected under the influence of high temperature and steady pressure. Subsequently to this deep-seated chemical alteration, mountain-making forces made themselves felt along certain directions, crushing the rock to some extent, and (more particularly) inducing foliation in the sericite, and consequently, a certain amount of fissility in the rock. This effect has seldom been sufficiently pronounced to produce a general foliation of the whole and convert it into a true schist. The contact metamorphism that would result from the later intrusions if, as seems probable, there were more than one, must not be overlooked.

5. The tellurides of gold together with the associated carbonates of lime and magnesia and the secondary quartz have been introduced into the ore-body by solutions which found ready access along the planes of parting produced by the incipient foliation. That much of the chlorite has been introduced in the same way seems probable from its frequent occurrence in wavy bands; alumina is also present in the mine-waters (see p. 36).

So much will, I think, be conceded by everyone; indeed it has to a large extent been already stated in one or other of the papers quoted above. The question now arises: What was the original rock? It was admittedly igneous, and the microscopic evidence leaves, I think, no room for doubting that it was an acid eruptive. It will be noted that in no case is there any evidence of the existence of hornblende, nor has the chlorite ever the appearance of being a pseudomorph after that mineral. Chlorite moreover, is rather a pigment than an important constituent, and in the analysis just quoted it will be seen that the percentage of alumina is very low. As already noted, quartz is not only a constant constituent, but it is even now in considerable quantity and has formed part of large individuals; this not only points to an acid rock, but, by reason of the abundance of the quartz, excludes quartz diorite. It would be preferable to leave the question of nomenclature till further evidence is forthcoming. Specimen 8508 from the one hundred and forty foot level of the Australia East Lease, affords a most valuable clue, however, inasmuch as, while agreeing with the others in the presence of titaniferous iron-ore and the nature of the alteration undergone, it is not so highly altered

as they are. As already stated (p. 34), it is a quartz-orthoclase-plagioclase rock containing ilmenite and apatite. This rock is holocrystalline and must be regarded as granitic. On the other hand, the micropegmatitic structure might occur in a porphyry as well as in a rock of granitic structure. Further, specimen 8462 (country rock from the Lake View and Boulder Junction) has a pronounced felsitic aspect, and certainly appears to be a felspar-porphyry; but the presence of titaniferous iron ore links it with the other specimens. There is nothing improbable, however, in the conception that we may be dealing with an ancient complex of acid eruptive rocks; moreover, it is quite in keeping with our knowledge of eruptive masses to regard them as varying in texture and structure from place to place. There is, therefore, no reason why the original rock may not have been granitic in some parts and porphyritic or felsitic in others.

Can any explanation be afforded for the opinions previously expressed that the Kalgoorlie country is dioritic? The word "diorite" is the shibboleth of the Australian working miner; by him it is applied with calm indifference to any rock, sedimentary or igneous, hard or soft, and is devoid of all meaning. Mine Managers, and others, however, have a tendency to class as diorite any green rock of moderate hardness. It was natural enough, therefore, that from the first discovery of the field, the dark-green country rock at Kalgoorlie should be called diorite. That dykes of diorite and amphibolite do occur in considerable abundance in the West Australian Gold-field country is evident enough. One such traversing North Kalgoorlie has already been referred to in this paper, while other specimens from Coolgardie and elsewhere are in the collections of the Mining Museum, Sydney. Such dykes are referred to in unmistakable terms by the authors quoted above. But Herr Schmeisser * can, I think, be only understood to mean that specimens coming from the two hundred foot-level in the Great Boulder, from the one hundred and ninety-three foot-level in the Ivanhoe, and from the one hundred and ninety-eight foot-level in Hannan's Brown Hill are hornblende-bearing rocks. This would make it seem probable that other amphibolite dykes may exist on the Kalgoorlie Field as is surmised by Mr. Bancroft †. It may well be that portions from such assumed dykes, showing, as they might be expected to do, hornblende macroscopically, would be selected for examination as being less altered portions of the country rock.

For the elucidation of the precise nature of the original rock, I think we must look, not so much to specimens from deeper levels—as these will be just as much changed by deep-seated metamorphic agencies as the rock just below the zone of surface weathering—as to those taken from cross-cuts and other situations as distant as possible from the ore-bodies and the crushed zone.

* *Op. cit.* p. 44.

† *Vide* p. 20.

A somewhat analogous mode of occurrence may be instanced from South Africa. Messrs. Hatch and Chalmers* state that metamorphic rocks and schists constitute the gold belts of the country (Rhodesia), and occur as broad bands and patches in granite. Chlorite and hornblende schists occur which are regarded as having derived their foliated structure from a mechanical process analogous to "shearing," referable to crust movements along zones of weakness. Their theory is that earth shrinkage first permitted the extrusion of igneous rocks, and then, continuing along the same line, converted them into schists and some of the granite into gneiss, at the same time opening fissures in which quartz was deposited. They consider that there is an intimate connection between the schists and the quartz, and that the ore will continue in depth.

If one might venture to sketch out the possible course of events at Kalgoorlie it would be somewhat as follows: A very ancient body of acid eruptive rocks—in part granitic, in part, perhaps, porphyritic—underwent intense alteration under the influence of chemical and other changes resulting from the great pressure and temperature prevailing at great depths within the crust. That this rock need not necessarily be Archean is indicated by the presence of true sedimentary slate, in which, as I am informed, fossils have been found † The acid rocks were subsequently intruded by more basic eruptives which have undergone similar deep-seated alteration, and now constitute amphibolites and altered diorites. Mountain-making forces then manifested themselves along lines of weakness, resulting in the shearing and crushing of the rocks (of whatever description) along these lines, and their partial foliation. Along the divisional planes of the rock occupied by this sheared zone mineralising solutions made their way, giving rise to the ore-bodies. It is highly probable that this district may have been very elevated in early geological time; it has apparently never since been underneath the sea, and the agencies of erosion have now reduced it to a table-land. The absence of running water in recent geological time has allowed the accumulation *in situ* of the products of atmospheric weathering, the decomposed zone sometimes extending down to the two hundred foot-level in the mines.

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† Specimens of these have been kindly sent to the Author by Mr. Bethune, of Boulder City, Kalgoorlie. These appear to be pyrite nodules only. The supposed fossils were referred to in a paper (see No. 5 of the Bibliography, by Mr. Corbin, recently read in Adelaide. Judging from the discussion, the general opinion of the meeting seems to have been against an organic origin.

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III—On the Occurrence of the Genus *Endophyllum*, Ed. and H. (emend. Schlüter) in the Lower Palæozoic Rocks of N. S. Wales: by R. ETHERIDGE, Junr., Curator of the Australian Museum, Sydney.

[Plates IV and V.]

THE specimen about to be described, and which it is proposed to call *Endophyllum Schlüteri*—as a slight expression of the value of Dr. Clemens Schlüter's work amongst Palæozoic corals—appears to have formed a portion of a weathered and even perhaps a rolled block. It is five inches in height, and five and a half inches in transverse measurement, but the precise outward shape of the corallum, beyond that it was "massive," cannot be ascertained. The corallites were large, long, and loosely connected by vesicular tissue, for in the above space of five and a half inches, there are only four, or perhaps five, corallites preserved.

The structure of this coral is best ascertained by the examination of vertical sections (Pl. IV, Fig. 1; Pl. V, Figs. 1 and 8). The corallites are cylindrical, from four to five-eighths of an inch in diameter, without a true outer wall, but defined laterally by out-growths, ultimately forming a series of much-arched, superimposed, opaque, thickened floors. The septa consist of strong vertical lamellæ sometimes slightly flexuous, the interseptal loculi being filled with horizontal, oblique, inclined, or slightly concave dissepiments, at variable distances apart. The thickened floors of the intercalicular tissue are strongly arched upwards once, or several times, between every two corallites, according to the distance apart of the latter, and themselves become vesicular in consequence of frequent inosculation, the opaque tissue so formed being strong and well marked. The resulting vesicles are variable in size, some large, others small, those forming the crowns of the arches with their convex surfaces upwards, those forming the sides of the saddles with their similar faces directed towards their respective corallites. Some of the vesicles are filled with clear calcite, others with black mud. The interstices between the thickened floors are either devoid of structure and filled with mud, or occupied by a second vesicular tissue more delicate than that of the floors, and unthickened, but following the same rules as to its general character. The whole of the vesicles are in section elongately lenticular. Nothing shows the part played by these floors in forming the spurious corallite walls better than a vertical section (Pl. IV, Fig. 1), for when immediately diverging from the corallites they are often thicker and closer than elsewhere, reminding one very much of the infundibuliform stages in the corallite growth of the genus *Blothrophyllum*. The distance apart of the floors in the intercalicular areas is very

variable, in some portions of the corallum following one another in rapid succession, in other parts well spaced apart. The upper surfaces of the floors are in places curiously dentate, giving forth a series of short, small, cone-like projections (Pl. V, Fig. 3.)

In a horizontal section (Pl. IV, Figs. 2 and 3), we observe, first, the immediate outline of the respective corallites, with an average diameter of half an inch. The septa are about twenty-eight, the thickened bases arising from the upward prolongations of the floors, and, as a rule, soon loosing their robust appearance, tailing-off into fine hair-like more or less curved filaments that either do not quite reach the centre, but leave a central tabulate area, or all but meet, and are partially and loosely curved upon one another, after manner of some *Zaphrentidæ*. There is an equal number of secondary septa, but as a rule they are quite short and cone-like (in section); occasionally, however, even these insensibly become filamentous at their distal ends, like the primary.

The appearance presented on cutting a transverse section (Pl. IV, Fig. 2) will of necessity vary much according to the point at which it is taken. Thus in Pl. IV, Fig. 2, the principal corallite, with its outer vesicular margin formed by the coalesced bases of the septa, is surrounded by a dark area, representing one of the large interstitial vesicles infilled with mud; but with exterior to it a more or less perfect ring represented by a floor arising from below the point at which the section happens to have been cut. In Pl. IV, Fig. 3, which is both a vertical and oblique cross section, the further meandering of this floor is visible, when it becomes apparent that the floor in question actually forms the boundary of the contiguous corallite giving off the thickened septal bases; outside this are the cut edges of other infundibuliform floors, sectioned in a similar manner. On the left of the first corallite (Pl. IV, Figs. 2 and 3), however, is another that has been cut with vesicular tissue infilling at least one of the interstitial spaces between two of the floors. A transverse section further explains the meaning of the tooth-like projections visible in Pl. V, Fig. 3, on the surface of the main floors; they are the thickened bases of new septa, their apparently vertical position being accounted for by the fact that in this section the floors are cut somewhat obliquely.

I am unable to describe the tabulæ in detail, my section having failed to cut any corallites in the proper situations. They are faintly shown in places in Pl. IV, Fig. 1, and Pl. V, Fig. 4, as fine close lines, and seem to unite with the vertical portions of the floors, to assist in forming the spurious walls of the corallites. Whether they are vesicular or no I cannot be sure, but from the appearance of the vertical section of the corallite seen in Pl. V, Fig. 4, I think they are.

The dissepimental tissue is either confined to a narrow ring round the margin of the corallites, or, in extreme cases, extends inwards for about one-half the diameter. (Pl. V, Fig. 5.)

The structure as seen under the microscope is very uniform throughout this coral. The whole tissue seems to be composed of a dark grey stereoplasmic matter, mottled with black of a faintly fibro-radiate structure. Only the septa, both in a horizontal and vertical section, seem to differ from this, the central line of each septum appearing to be of a lighter colour than the edges, but still there is no trace of a primordial septum. Under a high power the mottled appearance vanishes, and the whole colour is one uniform dark grey.

The genus *Endophyllum* was originally defined by Messrs. Edwards and Haime* as a composite coral possessing corallites united by rudimentary external walls and an irregular tissue, but with well-marked internal walls, accompanied by well-developed septa and small tabulæ. Two species were described and subsequently figured,† viz., *E. Bowerbanki* and *E. abditum*, the first of the two forming the type. Transverse sections, but unfortunately no vertical, were given. The structure of *Endophyllum*, as described by Edwards and Haime, was accepted as late as the appearance of the late Prof. Ferdinand Roemer's "Lethæa Palaeozoica,"‡ but more recently Dr. Clemens Schlüter, from later investigations into the structure of authenticated specimens of the type (*E. Bowerbanki*), failed to recognise either an inner or outer wall proper, the latter being simulated (in sections) by the bent cut edges of horizontal or curved floors, or lamellæ, connecting the various corallites. On to these floors Schlüter says the septa do not extend, whilst the interlamellar spaces are filled with vesicular tissue, more or less.

E. Schlüteri is in accord in every particular with Dr. Schlüter's definition§ of *Endophyllum*, except in one particular to be mentioned immediately. No more complete resemblance, from a generic point of view, could exist than between the sections of our coral and Schlüter's figures.|| Thus: the corallum is composite; the corallites circular, with distinct septa, but without proper inner or outer walls, separated by wide intercalicular spaces that are filled by curved (not horizontal in this case) lamellæ, or floors, which unite the corallites and assist in forming them, the interlamellar spaces being filled with vesicular tissue. Dr. Schlüter refers to the absence of the septa from the horizontal or curved lamellæ or floors of his specimens, and herein is the only point in which the specimen before me departs from the structure of *Endophyllum* as emended. It is at once apparent from the appearance presented by Pl. IV, Fig. 2, that the tooth-like projections on the upper surface of the lamellæ or floors, where the latter are either vertical or obliquely inclined, assisting to form the spurious corallite walls, are then in such a position to project inwards more or less horizontally towards the centre of the calices. In this position (Pl. IV, Fig. 2), it will be observed they become the bases of septa.

* Polyp. Foss. Terr. Pal., 1851, p. 393.
† Mon. Brit. Foss. Corals, Pt. 4, 1853, t. 52, f. 6, and t. 53, f. 1.
‡ Lethæa Geognostica. Theil I, Lethæa Pal., 1883, p. 354.
§ Abhandl. Geol. Specialkarte Preus. Thüring. Staaten, 1889, VIII, Heft 4, p. 50.
|| *Ibid.*, t. 6, f. 1-3.

A similar toothed appearance is visible on the intercalicular floors of *Darwinia speciosa*, Dyb.,* when viewed in vertical section, but of their further modification I am ignorant. Again they may be likened to the "erect spinules" of *Chonostegites Clappei*, Ed. and H., that occur on the upper surface of the tabulæ in this coral, and "which appear to represent continuations of the septa towards the axis of the visceral chamber."†

Of the two species originally referred to *Endophyllum*, Schülter retains *E. Bowerbanki* as before said, but rejects *E. abditum*. He also considers *Darwinia*, Dybowski, synonymous with *Endophyllum*, or at any rate certain species thereof, for instance, his own *D. perampla* ‡. It is to be presumed also, that *D. speciosa*, Dyb., and *D. rhenana*, Schl.,§ are so regarded, although I am not clear on this point, and if I do not misunderstand Dr. Schlüter, he appears to be somewhat in doubt himself. The macroscopic surface characters of the two last-named corals are known, whilst those of *E. Bowerbanki*, as Dr. Schlüter remarks to me, are not. It will not surprise me to find that the generic characters of the two corals referred to above, and that just mentioned, are ultimately shown to be distinct, for I have at hand at least one, if not two corals, that appear to accord better with Dybowski's definition of *Darwinia* (or whatever name the coral should be known by), than they do with some points in Schlüter's description of *Endophyllum*.

Loc. and Horizon—Isis River, Parish of Crawney, Co. Brisbane, New South Wales; Siluro-Devonian.

IV—Additions to the Permo-Carboniferous Flora of New South Wales, No. 2: by W. S. Dun, Assistant Palæontologist.

[Plate VI.]

I.—The Flora of the Greta Coal-measures.

But little detailed collecting has been done in the rocks of the Greta Coal-measures—the lowest fresh-water beds of the Permo-Carboniferous formation in New South Wales. On the whole the florula is characterised by the greater development of the genus *Gangamopteris*, the presence of *Annularia*, and taking into consideration the Ashford basin the relative abundance of *Noeggerathiopsis*. In the Hunter River Basin *Glossopteris* is relatively abundant at the expense of

* Archiv. Naturkunde Liv-. Ehst-Kurland's, 1873, V, Lief. 3, t. 2, f 8.
† Nicholson, Tab. Corals Pal. Period, 1879, p. 156.
‡ Sitz. niederrhein Gesellsch. Natur-u-Heilkunde in Bonn, 1881, p. 143.
§ Verhandl. nat. Vereines preuss. Rheinl. u. Westf., 1881, p. 196.

Gangamopteris which reaches its New South Wales maximum in the Ashford Beds. A very noticeable fact in the conditions of this vegetation is the absence of the very common Upper Coal-measure genus *Phyllotheca.*

The principal horizons of the Greta Measures, at present collected from, are Greta, West Maitland, Leconfield, four miles east of Richmond Vale, Anvil Creek, Russell's Tunnel, West Maitland, and Ashford.

From Ashford the following forms have been collected by Mr. H. G. Stokes:—

Glossopteris *cf.* communis, *Feistmantel.*
Gangamopteris angustifolia, *McCoy.*
„ cyclopteroides, *Feistmantel.*
„ „ *var.* subauriculata, *Feistmantel.*
„ spathulata, *McCoy* (?)
Noeggerathiopsis Hislopi, *Bunbury, sp.*
„ media, *Dana* (?)

Accounts of the geology of the Ashford Coal-field will be found in the papers by Professor T. W. Edgeworth David, B.A.,* and Mr. E. F. Pittman.†

From the Greta Series in the Hunter River District the following forms have been collected:—

Annularia australis, *Feistmantel.*
Glossopteris browniana, *Brongniart.*
„ „ *var.* præcursor, *Feistmantel.*
„ Clarkei „
„ elegans „
„ primæva „
„ tæniopteroides „
Gangamopteris, *sp.*
Noeggerathiopsis, *sp.*
Ovopteris alata, *Brongniart.*
Sphenopteris grandis, *Dun.*

These two last forms are of considerable interest, illustrating the presence of an additional family—the Sphenopterideæ—in these rocks.

II.—Sphenopteris grandis, sp. nov.

This well-marked and beautiful species (Pl. VI, Fig. 2) was collected at Denton Park, in the Parish of Gosforth, three miles north-west of West Maitland, by Professor David. It is contained in a grey, chalky shale, much slickensided.

The specimen is part of a pinna; on one side are two complete incised adiantiform, petiolate pinnules, and one perfect and two imperfect ones on the other. The nervation is very indistinct, but what little is preserved seems to show that it was

* Ann. Rept. Dept. Mines N. S. Wales for 1885 [1886], p. 130; Procs. Linn. Soc. N. S. Wales, 1893, VIII (2), p. 586

† Records Geol. Survey N. S. Wales, 1896, V, pp. 26–30.

only simply furcate. The degree of marginal incision is not great, and as far as can be judged there is only one nervure to each lobe—these incisions appear to be original and not of secondary origin or due to the marginal splitting of the pinnule. The pinnules are strongly flabellate and opposite, the largest one and three-eighths inches long by about the same width. Some of the incisions extend for about half the length of the leaf, but the majority are confined to an area from a half to a quarter of an inch wide along the margin. There is no serration along the margin, and the angle of incision is almost 90°. The stem is slightly fluted, and there are traces of two well-marked longitudinal ridges.

This Sphenopterid must, when perfect, have been of considerable size, and the general appearance is so imposing that I venture to propose for it the name of *grandis*. So far as I have been able to find, no hitherto described *Sphenopteris* approaches it either in size or form.

III.—Ovopteris alata, Brongniart.

(Pl. VI, Fig. 1).

Ovopteris alata. *Brongniart, sp.*

Pecopteris alata, Brongniart, Hist. Veg. Foss., 1828, I, p. 361, t. 127.

Aspidites alatus, Goeppert, Syst. Fil. Foss., 1836, p. 358.

Sphenopteris alata, Sternberg, Verstein. Flora Vorwelt, 1838, II, p. 131.

Sphenopteris alata, var. *exilis*, Morris, Strzelecki's Phys. Descr. N. S. Wales and V. Diemen's Land, 1845, p. 246, t. 7, f. 4.

Sphenopteris alata. M'Coy, Ann. Nat. Hist., 1847, XX, p. 149; M'Coy, Procs. R. Soc. V. Diemen's Land, 1851, I, p. 306; Unger, Gen. et Spec. Plant. Foss., 1850, p. 71; Schimper, Traité Pal. Végét., 1869, I, p. 411; Clarke, Remarks Sed. Form. N. S. Wales, 3rd Ed., 1875, p. 186. (Mines and Mineral Statistics of N. S. Wales, Philadelphia Exhibit. Handbook); Etheridge, R., junr., Cat. Austr. Foss., 1878, p. 99; Var. *exilis*. Clarke, Sed. Form. N. S. Wales, 1878, Ed. 4, pp. 121, 123, 155, 159; Var. *exilis*. Wilkinson, Notes on the Geology of N. S. Wales [Mineral Products, Ed. I], 1882, p. 52; *Op. cit.*, Ed. 2, 1887, p. 71; Feistmantel, Journ. Asiatic Soc. Bengal, 1876 [1877], XLV, No. 4, p. 357; Feistmantel, Pal. Indica, Foss. Flor. Gondwana Syst., 1880, III, Pt. 2, p. 77; Feistmantel, Pal. u. Mes. Flor. öst. Australiens., 1878, p. 87. [Palæontopafica, Suppl. Bd. III, Lief. 3, Heft. 1]; Var. *exilis*, *Op. cit*, p. 88; Tenison-Woods, Procs. Linn. Soc. N. S. Wales, 1883, VIII, Pt. I, p. 89; Var. *exilis*, *Id.*, *Op. cit.*, p. 90; Feist-

mantel, Sitz. K. B. Gesell. Wissen., Math-Naturwiss. Cl., 1888, p. 625; Var. *exilis*, Feistmantel, Sitz, K. B. Gesell. Wissen., Math.-Naturwiss. Cl., 188, p. 625; Feistmantel, Mem. Geol. Survey N. S. Wales, Pal. 3, 1890, pp. 88-89; Var. *exilis*. *Id.*, *Op. cit.*, pp. 89-90.

Ovopteris alata. Potonié, Flor. Rothliegenden v. Thuringen, Abhand. K. Preuss. Geol. Landesanst., n. folge, Heft 9, Th. 2, 1893, p. 44.

This species was first described by Brongniart in 1828 as *Pecopteris alata*, from the Hawkesbury River. In the same work he also described *Sphenopteris alata*, from the Carboniferous of Germany—this last form is now known as *S. Grandini*. The next to deal with the Australian species was Goeppert, who classed it under *Aspidites*, and Sternberg, in 1838, was the first to place it under *Sphenopteris*. Morris redescribed the species, from specimens collected by Strzelecki, as *Sphenopteris alata*, var. *exilis*, giving as synonyms Brongniart's *Pecopteris alata*, and Goeppert's *Aspidites*. There appears, however, to be no reason for the retention of the varietal name, and Morris was probably lead to this course from the fact that Brongniart in the same work had described his *Sphenopteris alata* (from Germany). The late Dr. Feistmantel* has, however, given strong reasons for the retention of Brongniart's name.

The original diagnosis, which I give here for the sake of comparison, was:— "P. foliis subtriangularis, basi tripinnatifidis, rachibus lævibus marginato-alatis, pinnulis basi confluentibus vel contractis, decurrentibus pinnatifido-lobatis, lobis magis minusve profundis, integris vel dentatis, nervulis pinnatis tenuissimus." Morris's description is only a translation of this.

Dr. Potonié, of Berlin, has been engaged for some years in a revision of the large and bewildering genus *Sphenopteris*, and in his recent Memoir "Die Flora des Rothliegenden von Thuringen,"† he defines a new genus *Ovopteris*, and gives a list of those species, most of them already referred to *Sphenopteris*, which he includes in it. Our *alata* is placed under this head.

Although the largest specimen at our disposal, that figured in Pl. VI, Fig. 1, is small, the general resemblance to *Sphenopteris polymorpha*, Feistmantel‡ will at once be seen to be very striking, and Feistmantel himself remarked on the similarity of the upper portions of the pinnæ, but he saw considerable difference in the lower pinnæ. Taking any of the figures on his Pl. XVA there may at once be seen differences between each of the figures and our specimens; for instance, in some cases the degree of incision is too great, in others the pinnules are more alate.

* Journ. Asiatic Soc. Bengal, 1877, XLV, p. 357; Pal. Indica, Gondwana Flora, 1880, III, p. 77; Mem. Geol. Survey N. S. Wales, Pal. 3, 1890, p. 89.

† Abhand K. Preuss. Geol. Landesarstalt 1893, neue Folge, Hefte 9 Th. II, pp. 39-45. The genus is also defined in the same Author's Lehrbuch der Pflanzenpalaeontologie, 1897, Lief. 2, pp. 141-143.

‡ Foss. Flor. Gondwana System. Flora Damuda and Panchet Divisions (Pal. Indica III, Pt. 2), 1880, p. 76, t. 15A, t. 16A, fig. 3, t. 16A bis., figs. 1-6; Journ. Asiatic. Soc. Bengal, 1876, XLV, pp. 356-358, t. 16, f. 5-7, t. 17.

The general disposition of the venation is however the same; and on the whole, allowing for the extreme variation to be seen between the different parts of a frond of these ferns, there can be no doubt that there is the closest relationship between the Australian and the Indian forms, and in our opinion there is reason to think that when more complete specimens of *alata* are examined it will be found that *polymorpha* is only a variety of it.

The specimen from Leconfield, in the Greta Coal-measures is rather indistinctly preserved in a soft grey shale, and agrees closely with Morris' figure in all points except perhaps the degree of alation of the rachis of which traces only are preserved. The pinnules are slightly larger and more ovate in habit. The venation is similar. It cannot be confused with Morris' *Sphenopteris lobifolia*,* and of the forms figured by Sir Frederick McCoy, the only one at all approaching it is his *S. hastata*† from Newcastle. This differs in the more elongate, narrow pinnules and pointed apices.

A few words are necessary as to the horizon from which Brongniart's original specimen was obtained. In his work, mentioned in the synonymy, he says, speaking of his *Pecopteris alata*—"Terrain houiller? Loc. Mines de Charbon d' Hawkesbury River, pres le Port Jackson, à la Nouvelle Hollande (Muséum de l'Université d'Edimbourg,)" and also, "Je n'indique le terrain dans lequel cette plante a été trouvée avec le *Glossopteris Browniana* et le *Phyllotheca Australis*, qu'avec doute." Now, I think, that although this Author gives the Hawkesbury River as the locality for these specimens, there is every probability of this being an error in labelling as (1) there are no coal-mines on the Hawkesbury River and (2) the association with *Glossopteris* and *Phyllotheca* points strongly to a Permo-Carboniferous origin such as Newcastle, where coal was mined at that time. Morris says‡:—"Associated with last species [*Sphenopteris lobifolia*] and *Glossopteris Browniana*, in a light coloured shale from Hawkesbury River, New Holland. The Museum of the Geological Society contains specimens of the two above-described species." "Locality—Newcastle Basin," has been added by Strzelecki. In contradiction to the locality given by Morris. Strzelecki gives without doubt the locality as Newcastle.§ McCoy,‖ in 1847, examined specimens from Newcastle, collected by the Rev. W. B. Clarke, and identified them as Brongniart's, and thus, in the light of the association and Strzelecki's remarks removes all doubt as to the species being considered as of Permo-Carboniferous, and not of newer origin, and completely answers Feistmantel's arguments, based on its occurrence. Mr. R. Etheridge, junr., remarked¶

* Strzelecki, *op. cit.*, t. 7, f. 3.
† Ann. Mag. Nat. Hist., 1847, XX, t. 10, f. 1.
‡ Phys. Descr. N. S. Wales and V. D. Land, 1845, p. 247.
§ *Op. cit.*, pp. 124-125, t. 5, fig. 1.
‖ Ann. Mag. Nat. Hist., 1847, XX, p. 149.
¶ Mem. Geol. Survey N. S. Wales, 1890, Pal. 8, p. 89.

in a footnote to the English translation of Feistmantel's work, speaking of McCoy's recording it from Mulubimba (Newcastle), "In all probability from the Hawkesbury Sandstone Series also"; but the previous argument will apply to this case as well.

From this I conclude of *Ovopteris alata*, Brongniart, *sp.*—

(1) It occurs in Permo-Carboniferous Beds, and in both the Greta and Newcastle Measures.

(2) That the often-quoted locality for this species of "Hawkesbury River" is due to an error in labelling.

(3) That there is no reason for the retention of Morris' varietal name *exilis*.

V.—On Stolzite and a new mineral, Raspite, from Broken Hill: by C. HLAWATSCH. *

[Plate VII.]

THROUGH the kindness of Professor Berwerth, Curator of the Department of Mineralogy and Petrography, Imperial Royal Natural History Museum, Vienna, I received in April, 1896, for examination, two specimens which Baron Heinrich Foullon-Norbeeck, who unfortunately lost his life during an expedition to the Solomon Islands, had received at Broken Hill, and which he had placed at the disposal of the above-named Institute for investigation. It was stated that there was on the specimens a new mineral, for which Baron Foullon proposed the name of Raspite, after Rasp, the discoverer of the mines at Broken Hill.

One of the specimens, called the first in the following remarks, consists fundamentally of decomposed galena with an efflorescent, black surface, on which are seated rather numerous crystals of tetragonal form, their colour varying from sulphur- to straw-yellow. On the second specimen there are found pyramidally developed, reddish crystals beside small, yellow-brown, monosymmetric tables on a limonitic basis. The yellow as well as the reddish crystals proved on investigation to be Stolzite, whereas the brown mineral, which is to be found also on the first specimen in sparse but somewhat larger crystals, does not possess an external appearance which corresponds with any mineral known to me. In fact the crystallographical and chemical investigations indicated that a new mineral was under consideration.

* Translated from the German by Mr. F. Bender. The original article appeared in Annalen K. K. Naturhistorischen Hofmuseums, Vienna, 1897, XII, Heft 1, pp. 33-41, Pl. 1, and the translation is published here by the kind permission of the Director of the Natural History Museum, Vienna. A few alterations have been made in accordance with the results of more complete examinations of the minerals, kindly communicated by Dr. Hlawatsch.

Measurement by means of the goniometer with two circles, as designed by V. Goldschmidt * of Heidelberg, was employed in the crystallographical investigation of these minerals; it was carried out under the direction of Professor Goldschmidt, and was performed according to the before-mentioned method, in an essentially simplified manner. As regards the use of symbols and the drawing of crystals, it may be suggested that reference be made to the two works "Index der Krystallformen" † and "Ueber Projection und graphische Krystallberechnung" ‡, as well as to the article "Ueber Krystallzeichnen" § by Dr. V. Goldschmidt. For the purpose of affording a better understanding of the terms occurring in connection therewith, it is proposed to explain their meaning by the aid of diagrams. Fig. 1 represents the stereographic projection. Let s indicate a point of a projection of a plane on it, $\phi = \angle\, b\, c\, s$ and $\rho = c\, s$ are the angles of position obtained on the goniometer with two circles. $\xi = sf$, $\eta = se$, $\xi_0 = e\, c$, $\eta_0 = fc$ are angles adopted also in the table of angles, and they are characteristic for the plane s. To what extent they correspond with angles of the inclination of planes, as measured by means of a goniometer having one circle, immediately appears from the diagram. c represents the pole of the plane of projection; b the position of the plane 010; the line $c\, b$ denotes the first meridian for the computation of the angle ϕ. Fig. 2 represents the so-called gnomonic projection. As regards the second mineral, it is drawn for a monosymmetric crystal. In this diagram the measurements signify $\frac{d}{h} = \tan \rho = o\, s$, $e = \cos \mu = o\, c$, $h = \sin \mu$, $\tan \rho_{10} = \frac{p_0 - e}{h}$, $q_0 = \tan \eta_{01} = c\, d$, $p_0 = cg$; $p_0, q_0, r_0 = 1, \mu = 180 - \beta$ are the polar elements for a monosymmetric crystal. h appears in the diagram as radius of the basal circle. $o\, f = x_s$, $o\, g = y_s$, $o\, l = x_t$, $o\, k = y_t$, m indicates the direction which leads to the point of projection of the prism $\frac{1}{3}\infty$; this point lies in infinity. The elements of the linear calculation of the crystals are $a = \frac{q_0}{p_0 \sin \mu}$, $c = \frac{q_0}{\sin \mu}$, $b = 1$.

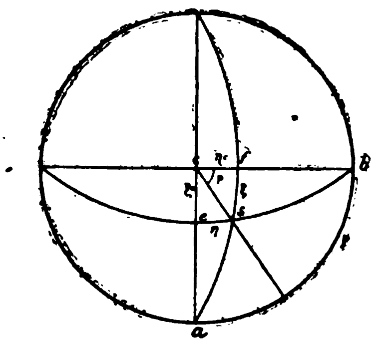

Fig. 1.

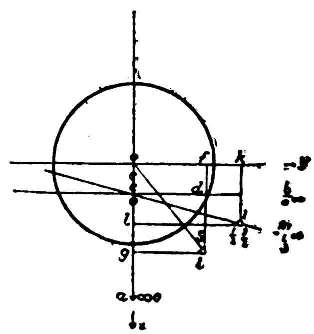

Fig. 2.

* Groth, Zeitschr. für Kryst., 1893, xxi, p. 210.
† Berlin, Julius Springer, 1886.
‡ Berlin, Julius Springer, 1887.
§ Groth, Zeitschr. für Kryst., 1891, 19, 352.

For system of crystallization of higher symmetry there is $h = r_0 = 1$, *d.i.* = the distance of the plane of projection from the imaginary centre of the crystal, the starting point of the plane normals leading to the points of projection. For the tetragonal system there is $p_0 = q_0$. $p, q, r = 1$ are the indices. When $p = q$, only one figure is put, *f*. *i.* Miller's sign (221) is = 2 for 2·2 according to this notation. So much as regards the notation and method of the measurement of crytals which have been employed. A description of the minerals and the results of measurements themselves may now follow.

A.—Stolzite.

As already mentioned, Stolzite occurs in two forms. The crystals of the first type form tables (which are translucent to transparent), or short, truncated pyramids of the combination (001), (011), (111), (023), π (133). (001) is sometimes very brilliant, sometimes corroded. Among the pyramidal planes (011) preponderates. On the same appears a great tendency of combination towards (011), (111). Inasmuch as it presents itself on both sides of (111), it often causes the appearance as if $\pi(\bar{1}33)$ existed, as the (011) ($\bar{1}$11) appears truncated. But in most cases the planes belonging to the form π ($\bar{1}$33) are missing. The pyramidal hemihedral character is clearly recognisable. But as quite feeble reflections were observed also from the form π ($\bar{1}$33) here and there, it has been shown beside (133) in the two diagrams of projection (Pl. VII, Figs. 1 and 2); the perspective drawing (Fig. 3) illustrates the hemihedral character. There is no certain sign of hemimorphism, as it is frequently observed in Wulfenite, and which Kerndt* also saw in Stolzite. In individual crystals, however, the base is more strongly developed on the one-half than on the other, but the planes existing on both sides are the same. Kerndt's diagram would even point to trapezohedral hemihedrism; but such is not to be assumed either from the formation of the planes on the crystals here spoken of, or from their optical action. The red-yellow crystals of the second specimen are translucent to sub-translucent. The continuation of growth parallel to the plane (111) here produces box-shaped forms. The combination is mostly (001), (111), (011), (034). The base is at times not represented at all; when it is met with, it exists only to a subordinate extent. In such a case it is rough, owing to the appearance of sub-individuals with the planes (111). (111) very much preponderates in these crystals. Hemihedral planes are totally absent, the form (034) takes the place of form (023) of the yellow crystals. On the whole these crystals show a development inferior to those from the first specimen, for which reason only one (No. VI., Table I) was submitted to measurement. Fig. 4 of the plate illustrates the form of this type. The reddish colour is probably due to the presence of more manganese.

* Erdm., Journ. f. pr. Chem, XLVII, 113. "Ueber die Krystallform und chemische Zusammensetzung des wolframsauren Bleioxydes," s.a. Table II, Fig. 1.

In regard to the following tables it may be remarked that the lettering of the planes was proceeded with in a manner analogous to that employed in connection with Wulfenite. In the tables of the computed angles, II and III, the planes $v = (112)$, $\mu = (221)$, $m = (110)$ were also inserted, which are given for Stolzite by other authors, but which are not represented in the material at my disposal.

Table I gives the results of the measurements of the different crystals; table II gives the computed values of angles for the measurement by means of the goniometer with two circles; and for it V. Goldschmidt's Tables of Angles, which are about to be published, have served as a model. Table III states a few somewhat more important computed angles of the inclination of planes, so as to afford a better comparison with measurements obtained by means of one circle; besides, a few angles measured by A. Levy and by Kerndt.

From the measurements is thus obtained the element $a : c = 1 : 1.5606 = p_0$, which was adopted as basis for the table of angles. It differs somewhat from that computed from A. Levy's * angles, which is $= 1.5692$, and from that of Kerndt's which gives 1,567. New planes for Stolzite are (034), (023) and (133). The latter was only recently observed by Ingersoll † in Wulfenite from New Mexico; (034) is not known even in Wulfenite.

In connection with the projections on Plate VII, Fig. I and 2, attention may be invited to the important position which (023) occupies in the combination of zones, likewise to the distinctness with which this combination shows itself in the gnomonic diagram of projection (Fig. 1).

Optical investigation reveals in convergent light a negátive uniaxial cross, which is surrounded by numerous rings (thickness of the crystal 1½ mm.). On rotating the object, the cross does not open out, whereas this phenomenon had already been frequently observed in connection with Wulfenite. The principal indices of refraction, determined by the application of prisms, are for sodium light:—

$$\omega = 2.270 \qquad \epsilon = 2.182.$$

* A. Levy—On a tungstate of lead. Ann. of Phil. Neue Serie, XII, 364.
† Groth, Zeitschr. f. Kryst., 1894, XXIII, p. 330

TABLE I.

OBSERVED ANGLES.*

Name.	Crystal I.		Mean Error.		Crystal II.		Mean Error.		Crystal III.		Mean Error.		Crystal IV.		Mean Error.		Crystal V.		Mean Error.		Crystal VI.		Mean Error.		Number of Observations.
	ϕ	ρ	ϕ	ρ	ϕ	ρ	ϕ	ρ	ϕ	ρ	ϕ	ρ	ϕ	ρ	ϕ	ρ	ϕ	ρ	ϕ	ρ	ϕ	ρ	ϕ	ρ	
	° ′	° ′	′	′	° ′	° ′	′	′	° ′	° ′	′	′	° ′	° ′	′	′	° ′	° ′	′	′	° ′	° ′	′	′	
e	00 02	57 23	03	06	00 00	57 20	01	01	00 00	57 20	02	01	00 00	57 20.	00½	01	00 00	57 20	01	01	00 00	57 21	17	04	33
p	44 58	65 40	03	03	45 01	65 36	01	08	45 00	65 38	00½	01	45 00	65 36	01	01	45 00	65 35	01	03	44 57	65 45	40	10	22
η	—	—			00 00	46 08	02	04	—	—			—	—			—	—			—	—			2
h	—	—			—	—			—	—			—	—			—	—			00 00	49 26	04	03	1
π	18 36	58 34	10	08	18 16	58 40	17	01	18 23	58 43	03	01	18 31	58 42	05	06	—	—			—	—			8
Element.	1.5631				1.5579				1.5597				1.5613				1.5586				1.5631				
Number of observations.			9				9				6				8								21		66

* The full-stop after the minute figures denotes that the value is from 0.25 to 0.75′ greater than the figures given.

TABLE II.

COMPUTED ANGLES.

Element $\left.\begin{matrix} c \\ p_0 \end{matrix}\right\} = 1{\cdot}5606$ $\log c = 0{\cdot}19329$ $\log a_0 = 9{\cdot}80671$ $a_0 = 0{\cdot}6408$.

Number.	Letter.	Symbol.	Miller (Bavais).	ϕ	ρ	ξ_0	η_0	ξ	η	x (Prisms) $x : y$.	y	$d = \tan \rho$
1	c	0	001	0	0	0	0	0	0	0	0	0
2	e	01	011	0	57° 20·9′	0	57° 20·9′	0	57° 20·9′	0	1·5606	1·5606
3	h	$0\frac{3}{4}$	034	0	49 29·4	0	49 29·4	0	49 29·4	0	1·1704	1·1704
4	η	$0\frac{2}{3}$	023	0	46 08·0	0	46 08·0	0	46 08·0	0	1·0404	1·0404
5	p	1	111	45°	65 37·5	57° 20·9′	57 20·9	40° 05·8′	40 05·8	1·5606	1·5606	2·2070
6	(υ)	$\frac{1}{2}$	112	45	47 49·0	37 57·9	37 57·9	31 35·9	31 35·9	0·7803	0·7803	1·1035
7	(μ)	2	221	45	77 14·1	72 14·1	72 1·41	43 36·1	43 36·1	3·1212	3·1212	4·4140
8	π	$\frac{1}{3}1$	133	18° 26·1′	58 42·3	27 29·0	57 20·9	15 40·6	54 09·5	0·5202	1·5606	1.6450
9	(m)	∞	110	45°	90°	90°	90°	45 00·0	45 00·0	1·0000	∞	∞

TABLE III.

COMPUTED Angles of the inclination of Planes.

Letter.	Symbol.	Hlawatsch. computed.	Levy. observed.	Kerndt. observed.	Letter.	Symbol.	Hlawatsch. computed.	Levy. observed.	Kerndt observed.
$c : e$	001 : 011	57° 20·9′	57° 30′	....	$p^1 : p^2$	111 : 1$\bar{1}$1	80° 11·6′	80° 17′	80° 15′
$c : \eta$	001 : 023	46 08·0	....	....	$\pi : e$	133 : 011	15 40·6	....	....
$c : h$	001 : 034	49 29·4	....	....	$\pi : p$	133 : 111	24 25·2	....	....
$c : p$	001 : 111	65 37·5	65 45	65° 42′ 23″	$\pi^1 : {}^1\pi$	133 : 313	44 56·0	....	....
$c : \pi$	001 : 133	58 42·3	....	....	$\pi^1 : {}^4\pi$	133 : $\bar{1}$33	31 21·2	....	....
$e^1 : e^2$	011 : 101	73 04·6	72 13	....	$(\upsilon^1 : \upsilon^2)$	112 : 1$\bar{1}$2	63 11·8	....	....
$\eta^1 : \eta^2$	023 : 203	61 18·0	....	....	$(\mu^1 : \mu^2)$	212 : 2$\bar{2}$1	87 12·2	87 14	....
$h^1 : h^2$	034 : 304	65 02·5	....	....					

The crystallographic characters resulted in its determination as Stolzite, and this was confirmed by chemical investigation. Professor Treadwell, of Zurich, in the kindest manner undertook the analysis, of which the result was:—

	per cent.
WO_3	51·34
PbO	47·44
MnO	0·78
MgO	Trace
Total	99·56

For the sake of completeness, the results obtained by means of the blow-pipe may be stated. In closed tube the mineral decrepitates strongly, without altering its appearance. On charcoal it fuses to an enamel-like glass with greater difficulty than Wulfenite; it does not show any separated globules of lead, and does not sink into the charcoal, but produces a slight coating of lead oxide. When treated with soda on charcoal in the reducing flame it yields light metallic lead. With salt of phosphorus in the oxidising flame the bead remains colourless; in the reducing flame it assumes, after longer treatment, a blue colour. The borax bead in the oxidising flame, a small quantity only being used, only becomes violet if it is dipped into saltpetre while hot. Heated in H Cl with the addition of metallic tin, the powder imparts a blue colouration to the liquid. After some time, the liquid assumes a red-violet hue, and after a period extending from twelve to twenty-four hours, it finally turns yellowish-brown.

In conclusion, it may be mentioned that Stolzite is also found on a specimen of ore from Broken Hill, which is in possession of Mr. A. Weisbach, Oberbergrath, at Freiberg, and he had the kindness to send it to me for comparison. The reddish crystals are here found situated in a crust of psilomelane on rock which is very rich in quartz. Whether this rock is closely allied to greisen, or corresponds with it, could not be determined. The crystallographic conditions nearly coincided with those mentioned above; a difference was presented only by the existence of much curved hemihedral prismatic planes. The planes (023), (034), (133) are absent; (111) prepondorated as compared with (011); the base was mostly very smooth, but small. My warmest thanks may here be expressed to Oberbergrath A. Weisbach, for his kindness.

B.—Raspite.

The other mineral which is found on the specimens appears in small, brown-yellow, transparent diminutive crystals of tabular habit. Their size varies from two and a half mm. to fractional parts of a millimeter. A crystalline crust, which can only with difficulty be separated from the stratum underneath, likewise consists of this mineral. On the first specimen there are situated, together with the yellow Stolzites, some crystals of this mineral, which, though their number is small, are

larger; but the bulk is found on the second specimen with the reddish Stolzites. Here, also, a difference between the two modes of occurrence is noticeable, as will be perceived from the following description:—The mineral is characterised by its bright adamantine lustre, its elongation in the direction of the axis of symmetry (Pl. VII, Fig. 8, which presents a single individual in normal position), its perfect cleavage parallel to (100), and its constant twinning parallel to the same plane. At times the twins are developed in the manner represented by Fig. 9 of the plate, especially so on the crystals of the first specimen; at times—and this is the case as regards the majority of crystals on the second specimen—in such a manner that the second individual is displaced in the plane (100) (Pl. VII, Fig. 10). More rarely a merging together of the individuals takes place; on the other hand a repetition of the twin-formation almost constantly occurs in Type II. A further point, which characterises especially the crystals of the second specimen, is the marked longitudinal striation on (100), which frequently causes a reflection much distorted by deflection of the rays.

As regards the distribution of colour: in many crystals, not far from the top edge, a deeper red-brown streak is visible, which is separated by a narrow, colourless streak from the more yellow-brown portion.

On the whole the crystals are very poor in planes. The planes $b = (010)$, $a = (100)$, $c = (001)$, likewise $d = (011)$, are well formed, and give pretty good reflections,—but only very imperfect reflections were obtained wherewith to prove the existence of plane $e = (\bar{1}01)$; by these the number of determinations sufficient for the determination of the crystallographic elements was obtained. Of the elements, therefore, q_0 and μ are well assured; for p_0 a confirmation would be desirable.

In connection with the results of measurement, it may be remarked that they were obtained by choosing (010) as pole. In this position is drawn also the gnomonic projection Fig. 5, in which the planes of both twin individuals are shown; but Figs. 6 and 7 present the projection in normal position.

The following tables are arranged in the same manner as for Stolzite (pages 55, 56) Table IV states the values obtained directly by measurement, *i.e.*, for the projection on (010). The values which have reference to the normal position are obtained by an easy transformation, inasmuch as for the zone of orthodomes $\phi_I = \rho$, $\rho_I = \phi$, for the clinodome (011) $\cot \phi_I = \frac{\cot \rho}{\sin \phi}$, $\cos \rho_I = \cos \phi \sin \rho$, if ϕ_I, ρ_I denote the angles for the normal position [plane of projection perpendicular to the zone (100), (010)], ϕ and ρ the angles of the measurement.

TABLE IV.

MEASURED ANGLES.

Letter.	Crystal I.		Mean Error.		Crystal II.		Mean Error.		Crystal III.		Mean Error.		Crystal IV.		Mean Error.		Number of Observations.
		ρ	ϕ	ρ	ϕ	ρ	ϕ	ρ	ϕ	ρ	ϕ	ρ	ϕ	ρ	ϕ	ρ	
b	∞	0	—	—	∞	0	—	—	∞	0	—	—	∞	0	—	—	4
a	89° 58′	90° ′	32′	05′	90° 06′	89° 59′	05′	02′	84° 49′	89° 59′	11′	03′	89° 58′	90° ′	02′	′0	11
c	17 36	90	05	02	17 55	90 00	16	02	17 46	90 00	04	03	17 21	90	15	03	14
d	17 59	43 25	35	4½	17 26	43 29	18	12	17 40	43 15	12	06	17 46	43 18	22	20	17
e	—	—	—	—	28 25	89 58	—	—	29 14	89 59	—	—	28 05	89 54	—	—	3
Number of Observations			14				·11				12				12		49

TABLE V.

CONNECTED ANGLES.

Elements.

$a=1{\cdot}3364$	$\log a=0{\cdot}12595$	$\log a_o=0{\cdot}08015$	$\log p_o=9{\cdot}91985$	$a_o=1{\cdot}2027$	$p_o=0{\cdot}83147$
$c=1{\cdot}1112$	$\log c=0{\cdot}04580$	$\log b_o=9{\cdot}95420$	$\log q_o=0{\cdot}02478$	$b_o=0{\cdot}8999$	$q_o=1{\cdot}0587$
$\left.\begin{matrix}\mu\\ 180-\beta\end{matrix}\right\}=72^\circ\ 19'$	$\left.\begin{matrix}\log h\\ \log \sin\mu\end{matrix}\right\}=9{\cdot}97898$	$\left.\begin{matrix}\log c\\ \log \cos\mu\end{matrix}\right\}=9{\cdot}48252$	$\log\dfrac{p_o}{q_o}=9{\cdot}89507$	$h=0{\cdot}9527$	$e=0{\cdot}3037$

Number.	Letter.	Symbol.	Miller.	ϕ	ρ	ξ_o	η_o	ξ	η	Prisms $\frac{x}{x:y}$.	y	$d=\tan\rho$.
1	*a*	∞0	100	90°	90°	90°	0	90°	0	∞	0	∞
2	*b*	0∞	010	0	90°	0	90°	0	90°	0	∞	∞
3	*c*	0	001	90	17° 41′	17° 41′	0	17° 41′	0	0·31882	0	0·31882
4	*e*	$\bar{1}0$	$\bar{1}01$	90	—28° 59′	—28° 59′	0	—28° 59′	0	0·5539	0	0·5539
5	*d*	01	011	16° 00′	49° 08′	17° 41′	48° 01′	12° 02′	46° 38′	0·31882	1·1112	1·1561

TABLE VI.

CORRECTED ANGLES.

Letters.	Symbol.	Angle.
$a : c$	$100 : 001$	72° 19′
$e : c$	$\bar{1}01 : 001$	46 40
$d : c$	$011 : 001$	46 38
$d : e$	$011 : \bar{1}01$	61 53·2
$b : d$	$010 : 011$	43 22

As regards its optical behaviour, the mineral is characterized by the following qualities:—Very high index of refraction (an investigation by means of the microscope according to the method of the Duc de Chaulnes showed approximately $n = 26.!$), hence very high adamantine lustre. The plane of the optic axes is the plane of symmetry; on (100) an axis and the negative bisectrix appear in a very oblique manner (outside the microscopic field of vision, Fuess, Obj. No. 7). Differences in absorption are noticeable; thus rays which vibrate parallel to $b = \mathfrak{b}$ are more strongly absorbed than those whose vibrations are perpendicular thereto.

A determination of density could not be accomplished owing to the small quantity of the material available. The hardness of the mineral is 2·5.

The chemical investivation gave a remarkable result. Prof. F. P. Treadwell, who had the kindness to undertake the investigation, succeeded, notwithstanding the small quantity of pure substance (0·1331 gr.), in carrying out the quantitative analysis. It showed:—

		Per cent.
WO_3	=	49·06
PbO	=	48·32
$Fe_2O_3 + MnO$	=	1·43
Total		98·81

The difference between the total and one hundred is to be accounted for by the fact that the quantity of available material was small. Treadwell presumes that the deficit is WO_3. He remarks expressly that magnesia, phosphoric acid, and vanadic acid are absent. The mineral has, therefore, like Stolzite, the formula: $PbWO_4$, in which a small portion of PbO is represented by FeO, MnO.

We have thus on the same specimen $PbWO_4$ in a double form—tetragonal and monosymmetric. As the combination (Fe, Mn) WO_4 also crystallizes in these two systems, and—which deserves more especial attention—as manganese partially represents lead in Stolzite as well as in the new mineral, the presumption

appears feasible that $PbWO_4$ belongs to an isodimorphic series*. But in view of the fact that it is so poor in planes, it would be promature to discuss the isomorphism with Wolframite, inasmuch as the most characteristic angle of the new mineral, (100) : (001) = 72° 19′, does not agree with any of the angles which in combination form orthodomes of simple index in Wolframite. The angle (011) : (010) = 43° 22′, (Wolframite $pe^1 = 40° 57′$, Descloizeaux, is alone similar as well as $(\bar{1}01) : (100) = 61° 23′$ (resp. $h^1 o^2 = 61° 54′$, Descloizeaux). We further find in both the twin formation in the direction of (100),† as well as the longitudinal striation on the same plane. The position of the optic axial plane is likewise the same‡. A cleavage in the direction of (100) exists in Wolframite only to a subordinate extent. The tetragonal form of (Fe, Mn) WO_4, Reinite, has also been investigated too little to be taken into account in this consideration.

As to the paragenesis of the mineral it may be observed that Stolzite appears to be the more recent product. With reference to the naming of this new, and certainly very interesting mineral, the Author deems it his duty to comply with Foullon's wish, and to propose the name chosen by this investigator unfortunately so early deceased. Accordingly the mineral would have to receive the designation "Raspite, Foullon."

In conclusion, I may be permitted to return my warmest thanks to all the gentlemen who assisted me in the investigation. Thus, to Professor Berwerth for kindly entrusting me with the material for operation, and for allowing me the use of instruments for several determinations. Further to Dr. Köchlin for his friendly help; and to Director Dr. A. Brezina, who drew my attention to the mineral. I am particularly grateful to Professor V. Goldschmidt, of Heidelberg, under whose guidance the investigation was carried out, and who most effectively aided me therein by advice and actual assistance; further to Professor F. P. Treadwell, of Zurich, who, in the kindest manner, undertook the carrying out of the analyses, and by them demonstrated the interesting fact of the dimorphism of Pb WO_4. Lastly, I also thank Professor Rosenbusch, Privy Councillor, of Heidelberg, and Professor A. Schrauf, of Vienna, who allowed me the use of the instruments for the optical investigations.

* Groth, Tabell. Uebers. d. Miner, III Aufl., Braunschweig, 1889, pag. 60.

† Levy, Descr., 1847, Taf. 79, Fig. 9; Descloizeaux, Manuel, 1893, Taf. 64, Fig 386.

‡ Descloizeaux, Ann. Chim. Phys., 1870, 4–19, 169.

VI.—On the Structure and Mode of Preservation of *Receptaculites australis*, Salter: by R. ETHERIDGE, Junr., Curator of the Australian Museum, and W. S. DUN, Assistant Palæontologist.

[Plates VIII-X.]

I.—History.

THIS interesting fossil has been known since 1859; but notwithstanding this, all that has been written about it, is the original short description by the late Mr. J. W. Salter,* and brief references by the late Professor Ferdinand Roemer † and Dr. G. J. Hinde. ‡ The late Rev. W. B. Clarke, in a list of New South Wales fossils, recorded another, *Receptaculites Clarkei*, Salter. § This form, however, was never described by Salter, who elsewhere says that the species is synonymous with *R. australis.* || Clarke also records, evidently on Salter's authority, the occurrence of the well-known *Receptaculites Neptuni*, Defrance, from between Wellington and Molong. ¶ The original examples of *R. australis* were obtained at Yarradong by the late Rev. W. B. Clarke, the only other recorded N. S. Wales locality being the Wellington Caves, by the late Professor A. M. Thompson, ** but this occurrence has not, at least to our knowledge, been verified.

II.—Terminology.

Each writer who has written on *Receptaculites* has made use of his own terminology, and we have found it very difficult to abide by one that shall, in a general way, be common to all; in fact, the terminology entirely depends on the view adopted as to the nature of *Receptaculites*, whether the structure as we now see it is to be regarded as that of the organism itself, or simply as a secondary replacement of the latter. Some authors have adopted the first course, others the second. Every term made use of by us will be explained once and for all the first time it is employed; and as the condition of our specimens renders terminology comparatively easy, it will therefore be expressed in simple language.

* Canadian Org. Remains, Dec. 1, 1859, p. 47, t. 10, f. 8-10.

† Lethæa Pal., Lief. 1, 1880, p. 290.

‡ Quart. Journ. Geol. Soc., 1884, XL, pp. 798, 844.

§ Clarke's Southern Goldfields, 1860, p. 286; R. Etheridge, Junr., Cat. Austr. Foss., 1878, p. 3.

|| In W. B. Clarke's Sed. Form. N. S. Wales, Ed. 4, 1878, p. 151.

¶ Sed. Form. N. S. Wales, Ed. 4, 1878, p. 16.

** Explor. Caves and Rivers New South Wales, N.S. Wales Parl. Papers, 162-A, 1882, p. 12.

III—General Structure.

So much has now been written on the supposed general structure of *Receptaculites*, both the macroscopic, and in a lesser degree the microscopic, more particularly by Billings, * Dames, † Gümbel, ‡ Roemer, § Hinde, || Winchell and Schuchert, ¶ Rauff, ** Girty, †† Schlüter, ‡‡ and Geinitz, §§ that it is not our intention to touch on this branch of the subject, but to confine our remarks to that of *R. australis*, based on the material in the collection of the Geological Survey of New South Wales and the Australian Museum, Sydney.

We may state that our examination of the Australian fossils, on the whole, supports the descriptions by the late Mr. E. Billings and Dr. Hinde.

So much discrepancy exists between the various descriptions of *Receptaculites* that it is most difficult to arrive at any satisfactory conclusion as to its original structure, especially when we find so experienced an observer as Dr. Hinde remarking " that it is doubtful if a single specimen has yet been discovered in which the original structure has been preserved,|||| and again, " the extraordinary diversity of appearance which *Receptaculites* and its allies exhibit, according to the different conditions in which the skeleton is preserved, stands also in intimate connection with the question of its original nature."¶¶

Too little attention has been given to this point, for, as Girty has truly remarked, " specimens hitherto supposed to represent true structure are probably only casts or infiltrations.*** In no single instance have our specimens revealed any trace of the original tissues, nor even of empty moulds, but in every case the organism is represented as a secondary replacement by mineral substances of the most complete nature. It naturally follows that many of the more minute details noticed by other writers will be found to be wanting here, if they ever existed.

IV.—Receptaculites australis, Salter.

Form.—Our specimens are all more or less fragmentary, and in consequence it is difficult to speak with exactness on the vexed question of the outward form of *Receptaculites*; but we have before us natural sections of the organism taken at all angles, from mere fragments to much larger portions of the outer and inner

* Pal. Foss. Canada, 1865, Pt. 5, p. 378.
† Zeits. Deuts. Geol. Gesell., 1868, XX, p. 483.
‡ Abhandl. K. Bayer. Akad. Wissensch., 1875, XII, Abth. 1, p. 170.
§ *Loc. cit.*
|| *Loc. cit.*
¶ Geol. Nat. Hist. Survey Minnesota, 1885–92, III, Pt. 1, 1895, p. 56.
** Abhandl. K. Bayer. Akad. Wissensch., 1892, XVII, Abth. 3, p. 645; Zeits. Deuts. Geol. Gesell., 1888, XL, Heft 3, p. 606.
†† 14th Ann. Rept. State Geol. N. York for 1894 (1895), p. 271 *et seq.*
‡‡ Zeits. Deuts. Geol. Gesell., 1887, XXXIX, heft 1, p. 26.
§§ Quart. Journ. Geol. Soc., 1884, XL, p. 808.
|||| Zeits. Deuts. Geol. Gesell., 1888, XL, p. 17 *et seq.*
¶¶ *Op. cit.*, p. 804.
*** *Loc. cit.* p. 281.

surfaces, forming parts of curved, more or less platter-shaped expansions, as described by Dr. Hinde, to portions that in some instances give the idea of oblong or cylindro-conical bodies. On the whole, therefore, we feel constrained to regard the platter-shaped pieces as portions only, and to accept the outward shape of *R. australis*, at any rate, as some modification of the form previously suggested. As illustrative of this, Pl. VIII, Fig. 4, shows a portion of an elongate, compressed cylindro-conical individual presenting two sides with intermediate convexities worn off. We certainly have not seen a wholly enclosed body as diagrammatically figured by Billings and believed by Rauff to be more the outward form of *Receptaculites*, with hollow central cavities, all platter, bowl, or cup-shaped pieces being, according to the latter, incomplete remains. Our specimens are clear on this point, inasmuch as they show that Billings and Rauff's conception of a hollow central cavity is in all probability correct. In the light, therefore, of discoveries made since Dr. Hinde wrote the statement that *Receptaculites* consisted of cup or platter-shaped bodies only is no longer tenable, for *R. mammilaris* (Newberry), Walcott,* is said to be often of an inverted conical shape, *R. elongatus*, Walcott,† is cylindro-conical, with a deep central cavity; and *R. ellipticus*, Walcott,‡ is an elongated, flattened, curved form, with an elliptical section. Nor must it be forgotten that Mr. G. H. Girty,§ has recently described the shape of *R. infundibuliformis*, as "pine-cone shaped," and he further states that the form of the Lower Helderberg examples generally support the views of Billings and Rauff. We have not been fortunate enough to observe any apical or other orifice in our specimens, as suggested by Billings, but we have before us one example from the Australian Museum Collection with a well-marked nucleus, or as it is termed by Rauff, "the lower pole," with the central nucleal point certainly concave, and a strongly-marked conjunction of the columnar elements. This specimen is figured in Pl. X, Fig. 8.

One of our examples displays a surface five inches long by three broad, in section, with one of the sides curved at almost a right angle, giving one the impression of a more or less cylindrical body. Another, with a continuous outline of the wall vertically weathered, suggests a body with an oval section, and so on. On the other hand, the Yass District specimens are circular in section (Pl. IX, Fig. 3), and in their present condition certainly platter-shaped, but they are clearly only fragmentary, and portions of much larger bodies.

Chemical Composition, Mineral Structure, and Mode of Preservation.—Dr. Hinde remarks that crystalline calcite is the most common condition in all *Receptaculites*, is met with at different localities and in various formations,‖ and is not the original

* Mem. U. S. Geol. Survey (Powell's), 1884, VIII, p. 65, t. 11, f. 11.
† *Ibid.*, p. 66.
‡ *Ibid.*, p. 67, t. 11, f. 12.
§ 14th Ann. Rept. State Geol. N. York, for 1894 (1895), p. 272.
‖ *Loc. cit.*, p. 806.

structure of the organism.* The Australian form occurs under two conditions—either wholly crystalline calcite, or partly this mineral and partly crystalline quartz. In the first instance, therefore, such specimens fall into Dr. Hinde's second section, but in the second they assimilate themselves to that subsection where the "skeleton" may be partly of calcite and partly of silica†; no entirely siliceous example has come under our notice, but in every case the mineral constituents are of secondary deposition.

We are acquainted with *Receptaculites* in Australia in limestone rocks only, and the associated fossils invariably partake of the same composition as the former; but in one instance some of the associated fossils show traces of chalcedonic structure. Every trace of organic tissues has been removed, and none of the parts have any special wall-substance, although all are well and clearly defined against the enclosing matrix, whether it be light or dark. The matrix is, in most cases, in a very finely divided slate, and completely fills all the interspaces between the outer and inner walls. There is, however, this difference between our *Receptaculites* and its associated fossils, that, wherever the latter have been microscopically examined, their walls always show a thin external pellicle of organic tissue.

The composition of our specimens from the principal localities is as follows:—

1. *Yass*—Crystalline calcite with traces of crystalline quartz, in a yellow-drab limestone.
2. *Fernbrook*—Entirely crystalline calcite, without quartz at all, or present only in an infinitesimal degree.
3. *Murrumbidgee River*—Crystalline and granular calcite with crystalline quartz in varying quantities, in a blue-black limestone.
4. *Goodrabigbee River*—The same condition as in the Murrumbidgee specimens.
5. *Tarago, near Goulburn*—Chiefly calcite in a fine state of division, with a little granular quartz, in a blue-drab limestone.
6. *Belubula River*—The same as those from the Murrumbidgee River, in a grey-blue limestone.

Specimens from the Murrumbidgee Valley are preserved in a deep dark-blue, almost black, limestone; those from Tarago in a similar rock of slightly lighter colour; those from Yass, in a yellow-drab limestone; those from Fernbrook, in a light-grey to greyish-white limestone; and that from Belubula in a grey-blue limestone.

The whole of the skeleton in the Australian specimens is amalgamated into one continuous crystalline mass, including the rhomboidal plates of both surfaces, the tangential rays, and the columns with their pediments, the crystalline constituents varying in amount in the respective parts, but the calcite always predominating

* *Loc. cit.*, p. 804.
† *Loc. cit.*, p. 803.]

over the silica, and the latter always occupying a central position surrounded by the calcite. There are exceptions to this, however, in the case of the specimens from Parish of Warroo, Co. Murray, Murrumbidgee, where all the organisms in the rocks are silicified. In this case the conditions are reversed, the outer parts being composed of silica. Two of these specimens are figured in Pl. IX, Figs. 9 and 10. Both constituents are, as a rule, coarsely crystalline, but in a few instances, particularly in the case of the columns, the calcite when by itself is finely granular. In one of our sections there are traces of a columnar calcite, but no trace of a finely fibrous crystalline structure in the strict sense of the word, such as is described by Gümbel, and confirmed by Rauff, has been observed, nor of any concentric layers deposited round a centre.

Dr. Hinde remarks that it is a noteworthy circumstance to find in specimens partly calcareous, partly siliceous, "that whilst in the siliceous portion of the specimens the interior canals are clearly shown in the spicular rays (tangential rays), no traces of them appear in those parts which have been replaced by crystalline calcite.* No such structures are visible in any of the specimens now before us, whether composed of one mineral or the other.

There is absolutely no trace of any pellicle or test in any of our specimens, but in weathered examples the exterior of the columns and tangential rays is stained with oxide of iron, which gives to these parts the appearance of a pellicle or wall; a microscopic section, however, at once dispels the illusion.

Gümbel described his Silurian *Receptaculites* as composed of a finely fibrous crystalline material that may have been arragonite in the first instance,† and Girty agrees so far as to say that the original calcareous test was probably arragonite,‡ Hinde, on the contrary, arguing "that if the Receptaculidæ are allied to Sponges, the proof for which must be sought from other considerations, their spicular skeleton was originally composed of silica."§ It seems to us that the organism we are now dealing with was originally calcareous, then altered into calcite, a subsequent infiltration of silica taking place and filling up cavities and cracks.

Poles.—Only one example with any trace of a pole has been observed (Pl. X, Fig. 8), consisting of a nucleal depression from which the columns radiated outwards in curved lines, all round what was originally a central point. In the median line on the two opposite sides of the latter the columns are much smaller and closer, otherwise the specimen is too much worn to yield further details.

Walls.—By the term "wall" we mean all that portion of the organism from the exterior to the inner surface inclusive, comprising within these boundaries the various "elements" or "meroms," as Rauff terms them, and forming the "body

* *Op. cit.*, p. 808.
† Hinde, *op. cit.*, p. 808.
‡ Girty, *op. cit.*, p. 281.
§ *Op. cit.*, p. 810.

wall" of Billings. Each is made up of the exterior rhomboidal plate, the tangential ray, the column, and the inner rhomboidal plate. In our specimens the wall is found in varying degrees of preservation, in a few instances with the exterior rhomboidal plates preserved, but more often with the latter denuded; in some instances with what we consider to be the inner rhomboidal plates, but always the columns; the tangential rays are seen in a few cases only. Practically this agrees with Billings' conception of the general test structure of *Receptaculites*, except that the inner rhomboidal plates seem to have been looked upon by him rather as a membrane. The wall in the Australian specimens has a fairly constant thickness, some specimens measuring fifteen, two seventeen and a half, another seventeen, and again one five and a half millimetres, according to position in the organism.

Exterior Rhomboidal Plates.—The rhomboidal plates of the "ectorhin," as they are termed by Billings; the head or summit plates of Hinde; "rhombischen täfelchen" of Rauff, are, either from the outside or inside, displayed in only a few specimens. On viewing them from the outside, they do not appear to differ essentially from those of *R. occidentalis*, Salter,* and are bounded by delicate linear interspaces, as described by Hinde, whenever the slightest weathering takes place, but where disintegration has not gone on they seem to abut close together. The linear separation on weathering seems to show that no anchylosis took place as Billings has suggested, for he remarks that " when silicified specimens are treated with acid the plates are easily separable." On a weathered surface they quite coincide with Billings' illustration.† Their shorter axes are in all probability in a meridional direction, similar to the specimens examined by Rauff, but on this point we cannot be quite certain, nor have we observed any trace of the overlapping or imbrication mentioned by this observer. In the majority of our specimens the exterior rhomboidal plates have been removed, exposing natural cross-sections of the columns. One example from the Murrumbidgee River displays a very remarkable appearance, in that these plates being weathered away, and the columns removed, the linear interspaces have widened out, leaving interrupted channels presenting somewhat the appearance of a transverse section of *Halysites*. On these plates we have quite failed to see any trace of the central knob described by Messrs. Winchell and Schuchert‡ on those of *R. Oweni*, Hall. Externally the plates are not flat, but slightly curved, thinning off towards the edges, which are thin and apparently sharp, and slightly concave on the inner side. Hinde describes them as flat, but we are more in accord with Rauff's description of those of *R. Neptuni*, as above. The average size is three by three and a half millimetres, or some appear to have both diagonals equal.

* Canadian Org. Remains, Dec. 1, 1859, p. 45, t. 10, f. 1-7.

† *Loc. cit.*, p. 381.

‡ Winchell and Schuchert, *op. cit.*, p. 58.

In weathered specimens, wherever the plates have been displaced, they are seen to have an appreciable thickness; but in vertical sections of the wall prepared for the microscope it is hardly possible to differentiate between them and the tops of the columns, unless indeed a capping of clear columnar calcite on the summits of some of the columns represents them. On the other hand, in other columns, instead of this clear capping, the tops of the latter present a ragged or frayed appearance, which we believe represents the roughened surface of Beekite rosettes developed at points where the secondary silica predominates over the calcite. In his description of *R. australis*, Salter refers to the "lower surface lobulated in larger or smaller divisions which seem to radiate from a central boss,"* of the expanded outer ends of the columns. This is nothing more than the conversion of this part of the organism into Beekite, a mineral by no means uncommon in connection with the organic remains of our Lower Palæozoic Limestones, and one that has already been described in detail by one of us.†

In the subject of Pl. IX, Fig. 8, we see the exterior rhomboidal plates viewed from above with the irregular or serrated edges, some close and touching, others separated by interspaces. One plate, and only one, has a central round aperture at about the point occupied by the top of the column. In this section are also to be seen, extending from under the plates in a downward direction and at corresponding corners in each case, one of the tangential rays, being parallel to the longer axes of the plates. All the plates are composed of granular, non-crystalline calcite, with here and there a small central patch of crystalline quartz. Mr. R. H. Girty makes the astounding statement that, in specimens of *Receptaculites* from the Lower Helderberg of New York State, there is no trace of the existence of exterior rhomboidal plates, and concludes that such were never present in the genus at all.‡ He describes the outer surface of *Receptaculites* as consisting of "ridges which start from a point, the basal pole (Rauff), and radiate spirally in two directions, after the manner of the engine-rolling on a watch. The ridges are thin, solid, high, and usually continuous. The rhombic depressions which they form are well-marked and deep. This description is true of both surfaces, but that one which is here called the gastral surface, has the reticulation much reduced, perhaps one-fourth the size of the other." His argument is, that the exterior rhomboidal plates described by Authors are simply an infiltration of the rhombic pits that he conceives formed the exterior surface of *Receptaculites*. If such be the case, it opens up an entirely new conception of the outward appearance *at least* of *Receptaculites*, and is fundamentally opposed to the teachings of Billings, Hinde, Rauff and others. All that we can say on this subject, from an examination of Australian specimens only, is that a calcareous replacement in the form of rhomboidal plates does exist on the exterior of *R. australis*, and that if Girty's

* Salter, *loc. cit.*, p. 47.
† Etheridge, Records Austr. Mus.
‡ *Op. cit.*, p. 273.

description of the outer surface of the Lower Helderberg specimens is that of the true external appearance of *Receptaculites*, then this has never so far been seen in an Australian specimen.

Columns.—We retain this term for the spindle-shaped bodies more or less at right angles to the inner and outer walls, and uniting them, and at right angles to the plane of the walls. They are the "vertical rays" of Hinde, "cylindrical tubes" or "hollow spicula" of Billings, the columns ("säulchen") of Rauff, and "radial tubes" of Girty. They vary in length according to their position in the organism, and are also variable in diameter and form, although the latter is always some modification of the fusiform or spindle-shape; but of whatever shape they may be, there is always more or less of a tapering or contraction at the two extremities, being thus in accord with the structure observed by Billings in *R. occidentalis.* They can hardly be described as "nearly cylindrical for the greater part of its (their) length," as stated by Dr. Hinde; although the latter has remarked that the neck-like contraction at the top and bottom seems to be generally characteristic of *Receptaculites.* The enlarged circumference of the spindle is also variable, it may be either central, or nearer the respective ends of a column. The average diameter is about two mm. Those of one spiral row are closely set, almost touching one another, but the rows of columns in general are separated from one another by much wider intervals. In all our weathered examples the surface of the columns is of a brown ferruginous colour, and practically smooth; but, as in no case, from our point of view, are we dealing with the real tissue of the columns, we are unable to say whether or no transverse furrows existed, or whether they were slightly corrugated as described by Rauff. We are quite unable to throw any light on the general existence or otherwise of an axial canal in the columns of *Receptaculites* from the peculiar mineral composition of our specimens; but, as they are preserved, there certainly is no canal or tube in them; nor have we any information to give on the question of the spindles, or solid axes, believed by Rauff to have existed, unless, indeed, the central vacuities in some of the columns filled by silica represent the spaces formerly occupied by spindles. The columns are continuous in one piece with the tangential rays, and are to all intents and purposes of the same mineral composition. In most cases where we have prepared micro-sections, the outer or surface ends of the columns are expanded, leaving cup-shaped hollows between them (Pl. IX, Fig. 2), or the intervening line between them is straight (Pl. IX, Fig. 9). In instances where the tangential rays have been broken off, the ends of the columns present the appearance of so many elongated vases with a crumpled periphery (Pl. VIII, Fig. 2).

The mineral structure of the columns appears under four aspects—1st, either with a crystalline siliceous centre (Pl. X, Fig. 6), with an outer area of crystalline calcite, exhibiting cleavage up to the well-defined margin; or (2) crystalline calcite

only (Pl. IX, Fig. 10) ; or (3) finely-granular calcareous matter only, as seen under high power (Pl. IX, Fig. 2) ; or (4) both the last-mentioned and crystalline calcite in the same specimens, but in separate columns (Pl. IX, Fig. 9). The line of crystalline quartz in the centre of the columns varies in diameter, whilst disintegrated cavities in the calcite have evidently been subsequently filled with crystalline quartz.

Girty considers that the columns, or, as he terms them, "radial tubes," or "canals," were really tubes and not canals, opening from the bottom of the rhombic pits, which, as before stated, he regards as the external aspect of *Receptaculites*, taking the place of the almost universally-described rhomboidal plates, * as we are led to believe from the appearance of our specimens that the columns represent tubes which became filled with calcite. The regularity with which the centres of the columns are filled with crystalline silica induces us to believe that after the deposition of the crystalline calcite a median vacuity was left, subsequently filled by the former as a secondary process. Dr. Hinde's view, † that the opinion held by some Palæontologists "that these fossils consisted of a series of hollow cylindrical cells" is erroneous, is on the contrary probably incorrect.

The inner ends of the columns are, as described by Billings, Hinde, and Rauff, expanded, forming what the latter calls pediments, "fusschen," these dilatations becoming united into a common surface. These pediments are composed of calcite, either crystalline or granular, with a little scattered silica. As a rule, the pediments abut closely against one another, and are equilateral, unlike those of *R. orbis*, figured by Rauff as boot-shaped, always projecting at the base regularly to one side. One of our specimens exhibits traces of cavities, more or less round, probably the cross sections of canals that are said to occur in this portion of the organism.

Rauff has denied the presence of canal perforations in the inner wall between the pediments, but a Reviewer‡ of his Memoir appears to us to be correct in saying that such are shown on his Pl. III, Figs. 10 and 10a.

Interior Rhomboidal Plates.—The inner layer of *Receptaculites* was described by Mr. Billings as the endorhin. Dr. Hinde says—"In *R. occidentalis*, the inner or upper layer appears to be fundamentally composed of modified extensions of the basal ends of the vertical rays of the spicules. Instead of tapering to a pointed extremity, as in *Ischadites* and *Acanthochonia*, the vertical rays in this species of *Receptaculites* continue cylindrical to near their basal extremities, and then abruptly expand into horizontal plates."§ It has not been possible for us to satisfactorily determine in our specimens whether this inner layer is only the expanded ends of the columns, or a separate series of plates, but we are inclined to

* Girty, *op. cit.*, p. 280.
† Hinde, *op. cit.*, p. 806.
‡ Geol. Mag., 1892, IX (3), p. 520.
§ *Op. cit.*, pp. 824-825

regard it as made up of the latter. It appears to us that these "plates" are as much rhomboidal as those of the exterior series, and furthermore that they are intimately united together, so as to form a continuous inner or "gastral" membrane, as described by Hinde.* In another specimen, at each angle of these plates is a circular pore (Pl. X, Fig. 2), the vertical hollows of Hinde,† and endorhinal pores of Billings.‡ It is also clear that these pores are formed as described by Hinde, by nicks cut out of the corners of each plate. On the other hand, they are regarded by Rauff as a secondary formation, whilst Girty denies the existence of them at all. Be this as it may, a micro-section of the inner or "gastral" surface shows not only these pores very distinctly, but under a very low power the rhomboidal divisions also. The pores are very regularly developed at each angle of the plates, but when the surface is at all worn by disintegration they become simply ragged unsymmetrical holes (Pl. X, Fig. 7). In one of our specimens the pores are connected by impressed lines or furrows, which also act as the boundaries of the plates (Pl. X, Fig. 2). In another example in which this layer is shown on a concave surface the plates are exposed over an area of four and a half by three inches, with their bounding furrows (Pl. X, Fig. 4). This layer has a thickness of a quarter millimetre. In a further specimen the plates are firmly attached to the ends of the columns without the expanded foot end described by Rauff, and apparently form one continuous membrane, which, however, regularly breaks up into the component rhombs on fracture or weathering (Pl. X, Fig. 8). Rauff denies the existence of these inner plates, regarding them as the roughly rhomboidal outlines of the enlarged inner ends of the columns, and due to a combination of pressure and erosion.

The altered condition of the Australian specimens has prevented the preservation of the canals said to penetrate the substance of these plates, as described and represented by Billings in his diagrammatic figure,§ unless the circular openings already referred to by us in the expanded pediment ends of the columns are connected with them. Such a case would, of course, tend to weaken the view we have adopted, that those enlarged ends, and the plates, are separate structures. The canals in question are regarded by Rauff as arising from imperfect secondary formation in the infilling of groves and furrows on the inner surface. On the other hand, if the canals do exist, then, as Girty has remarked, there is a clear distinction between the latter and those of the exterior rhomboidal plates.‖

Similarly, our thin sections have failed to reveal the vesicular structure that Girty appears to have made out in connection with the American *R. infundibuliformis*; nor have we noticed that the rhombic outline of these plates in our examples is in

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* *Op. cit.*, p. 825.
† *Op. cit.*, p. 825.
‡ Pal. Foss. Canada, I, p. 382, f. 357 c.
§ *Op. cit.*, p. 382, fig. 357.
‖ Girty, *op cit.*, p. 283.

any way smaller than that of the exterior rhomboidal plates. In thin sections we also observe that this inner layer of our *Receptaculites* is composed of granular calcite with a very little silica scattered through it.

Tangential Rays.—These are the stolons of Billings, horizontal rays of Hinde, and the tangential rays ("Tangentialarme") of Rauff, whose term we adopt. As weathered structures these rays are visible in only four of our specimens, but we have several sections showing them in a greater or less degree of preservation. Taking one specimen with the other, however, the appearances presented by them are so contradictory that we are unable to satisfactorily reconcile the structures exhibited.

In *R. australis* the tangential rays are four in number and certainly not spindle-shaped, but elongately conical or tapering, nor do they intersect one another at the centre of the rhomboidal plates. They radiate from the columns, two directed towards the poles, and two lateral in position, as described by Hinde and Rauff (Pl. IX, Fig. 6). We have already stated it as our opinion that the columns were hollow tubes originally; so in like manner were the rays, the one being continuous and opening into the other. We do not doubt for a moment the correctness of Rauff's statement, one previously hinted at by Hinde,* that these rays extended beyond the limits of their respective plates, for in more than one instance the rays are broken off short at the plate edges, thus being incomplete. The rays of one column did not meet end to end with those of adjoining columns as represented by Billings, but they undoubtedly overlapped as mentioned by Hinde,† a point very clearly shown in one of our specimens (Pl. X, Fig. 5). It naturally follows that as we look upon the rays as originally hollow we cannot subscribe to the presence of the axial canals of Hinde, or the spindles of Rauff.

Mr. R. H. Girty not only disbelieves the original existence of rhomboidal plates and columns,‡ but also of the tangential rays, and suggested that the latter are merely the casts of the four radiating stolons seen in the outer rhombic pits of his *R. infundibuliformis.*§

The foregoing facts comprise all we can say with certainty as to the nature of the tangential rays in our specimens, but the following is a description in detail of the four specimens exhibiting them. One from Cavan (Pl. X, Fig. 3), is an oblique, naturally-weathered section of the wall, presenting along the exterior edge several rhomboidal plates with tangential rays, perfectly horizontal, or in the same plane as the inner surfaces of the plates and firmly united to the latter. None seem to descend, as described by Rauff, nor to lie at different levels in regard to one another. Another, from Warroo, is in several respects a similar specimen, but in

* *Op. cit.*, p. 823.
† *Op. cit.*, p. 823.
‡ Girty, *op. cit.*, pp. 279, 282.
§ Girty, *op. cit.*, t. 3, f. 5, 6.

addition certain columns capped by the rhomboidal plates are visible in natural weathered section, but only in a very few instances are there any traces of tangential rays, and even then they are unsatisfactorily shown.

A third, from Goodradigbee (Pl. X, Fig. 5), is an exceedingly instructive example. It is the exterior surface of the organism seen from the inside, and in two places it shows the disposition of the rays in regard to one another. The columns have been fractured at the points indicated, just the points of origin of the tangential rays. Guided by Rauff's statement that the lateral rays are shorter than the meridional, we are able to roughly place this specimen in its natural position, but we are unable to decide which of the meridional rays is proximal and which distal. In this case, at any rate, there appears to be little doubt that the tangential rays are at different levels when those of adjoining columns are compared, even if they do not overlap, which we are inclined to think they do. And also, this specimen shows exceptions to Rauff's statement mentioned above in relation to longer and shorter axes and their directions, as in some cases rays of three different lengths occur on the same plate. Another point that is shown by the figure is, that the rays not only pass beyond the limits of the plates, but abut against adjoining columns in some cases, dovetailing with one another, in one direction passing to the right of the next column behind and to the left of the column in front.

Pl. X, Fig. 4, represents part of another specimen from Warroo. This is a test cut across near one of the poles, and is seen from the inside of the exterior surface. The centre is wholly occupied by the broken radial columns, but round the margin of the specimen a circlet of columns is visible, most of which have been broken off short just at the tangential rays. In more than one instance all four rays are seen radiating from a column. This specimen also shows many of the points noticed in the preceding one.

In a thin section of the wall we have already noticed the crumpling of the edge of the columns,—this we believe to be the inner edge of the fractured tangential rays; but in other cases, where the top of a column expands, an inclined arm is given off right and left from each, those on neighbouring sides of columns meeting in the middle line with a downward projecting point. Unless these are inclined rays we are unable to account for them, none of the naturally weathered specimens showing such a structure. Above this point is a semicircular hollow filled with the matrix, and containing a more or less circular spot of a similar mineral composition to the remainder of the specimen. We take these to be rays at right angles, viewed in section. Another of our sections, on the other hand, does not exhibit these downward projecting points, whilst a third section shows neither the latter nor the tangential rays.

V.—Summary.

The evidence as to form is by no means conclusive, but seems to support the view of Billings and Rauff that it was in some degree spherical or top-shaped, as against that of Hinde, who regards *Receptaculites* as a more or less basin or platter shaped body. It must not be forgotten that in no single instance have we seen the slightest trace of an original test, and are in consequence dealing with replaced structure only, precisely as did Billings and Hinde, and, to a great extent, Rauff also.

Whatever may have been the outward appearance, whether covered by a series of rhomboidal plates, or subdivided into rhombic depressions divided by ridges radiating spirally in two directions as described by Girty—whether formed of solid plates and spicules, or of tubes, as again supposed by Girty,—we must certainly, from the mode of preservation of our specimens, in a general way support the descriptions of Messrs. Billings and Hinde. Still, in a series of specimens the appearances presented are so contradictory, that at times there is to us a certan amount of evidence to support the opinion that Girty's conception of *Receptaculites* approaches nearer to the truth than that of any other writer who has investigated its structure.

Girty denies the presence of both external rhomboidal plates and tangential rays, and accounts for them by infiltration, first, of his rhombic pits, and secondly, of the four canals radiating towards each angle of the pits*; but no infiltration as here suggested by Girty, can account for the disposition of the tangential rays as shown by Rauff,† and also in our Pl. , Figs. . His canals do not pass beyond the boundaries of their respective rhomboidal pits, whereas the tangential rays do project beyond the edges of the rhomboidal plates, the meridional or lateral rays of one element overlapping those of contiguous elements. Such would not be the case were they the casts of short radiating canals. On the other hand, we do not agree with those who regard these rays as representing solidities, or the latter containing spindle-shaped bodies. We believe them to be the infilled casts of pre-existing tubes that diverged from the supporting columns, and these columns appear to us to have been also tubes, and not merely containing axial canals as stated by Dr. Hinde.‡ On this point we agree with Mr. Girty.

Much uncertainty exists as to the structure of the innermost layer of the organism, the endorhin of Billings, and our interior rhomboidal plate. By Billings and Hinde it was looked on more in the light of a membrane rather than separate plates similar to the external rhomboidal plates, and caused by the dilatation of the inner ends of the column; in this Rauff appears to join issue with them. On the other hand, to us there seems to exist definite plates, but the point is by no means proved.

* Girty, *op. cit.*, p. 282, t. 3, f. 5, 6.
† Rauff, *op. cit.*, t. 1.
‡ Hinde, *op. cit.*, p. 823.

As to the composition of *Receptaculites*, Mr. Girty says: "Hinde believes that it was siliceous; Rauff, that it was calcareous; Gümbel, that it was aragonite; and Billings, that it was calcite or in part coriaceous. These variations in results may be explained by the fact that infiltration products only have been investigated, the nature of the material being that which at the time was most plentifully dissolved in the sea-water of a given locality."* And again, "my own conclusions agree either with those of Gümbel that *Receptaculites* was originally composed of aragonite, or of Billings that it was chitinous." We have already said that our specimens present no traces of organic structure, but are composed of two separate replacements—one calcareous, the other siliceous—calcite first and silica afterwards. Beyond this we are not prepared to offer an opinion. As a Reviewer has very truly remarked,† the structure of *Receptaculites* must have been extremely liable to change.

VI.—Species.

From an examination of a large number of specimens, we have arrived at the conclusion that there is at present but one species represented in our collections—*R. australis.* No doubt isolated specimens, examined by themselves, show considerable variation; but we find there are regular gradations of size, wall thickness, not only between specimens from different localities, but also from the same individual.

VII.—Localities.

The localities represented in our series are:—Belubula; Fernbrook; Goodradigbee River, between Dutton's Grant and the river; Broomby, near Mudgee; Tarago, near Goulburn; Woolgarlo, near Yass; Por. 122, Parish Cavan, County Cowley; Por. 95, Parish Cavan, County Cowley. Por. 131, Por. 117, J. T. Hughes' 1,098-acre selection; W. Roberts, 968-acre selection, Parish Warroo, County Murray, Murrumbidgee.

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* *Op. cit.*, p. 284.

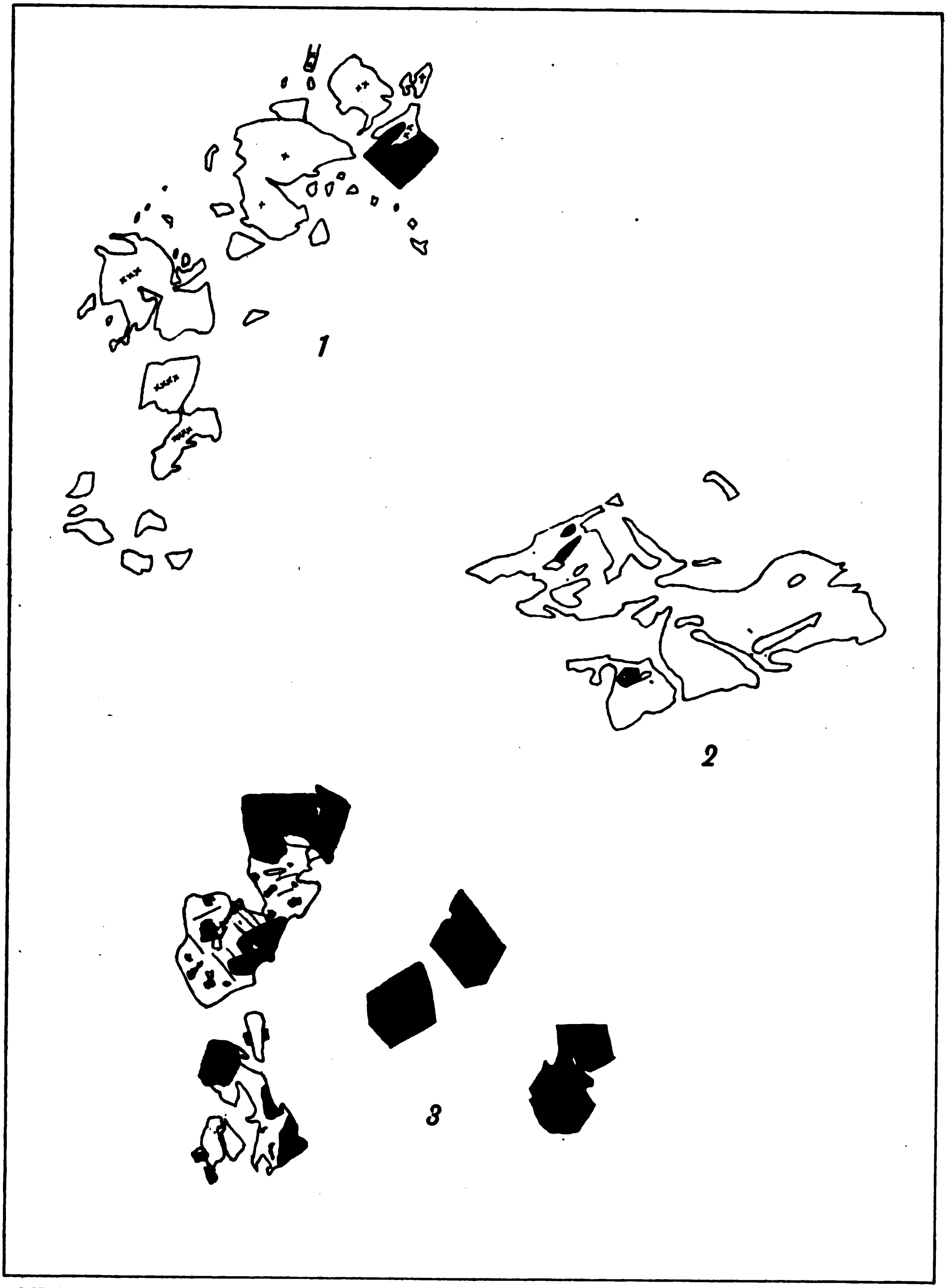
† Geol. Mag., 1892, IX (3), p. 519.

PLATE I.

Fig. 1. Quartz in country rock, Boulder Main Reef. x 20. Slide 1301. The innumerable quartz fragments are evidently portions of one or two individuals, but the different parts do not extinguish absolutely together. By means of crosses the grains extinguishing together are indicated. An outlying grain, with a single x, will be noted in the neighbourhood of other grains with two x's.

Fig. 2. An irregular grain of titaniferous iron-ore from the country rock of the Boulder Main Reef. x 20. Slide 1301B.

Fig. 3. Grains of iron ores (titaniferous and magnetic) from Boulder Main Reef. x 20. Slide 1301A.



G.W.C., delt.

PHOTO-LITHOGRAPHED AT THE GOVT. PRINTING OFFICE,
SYDNEY, NEW SOUTH WALES.

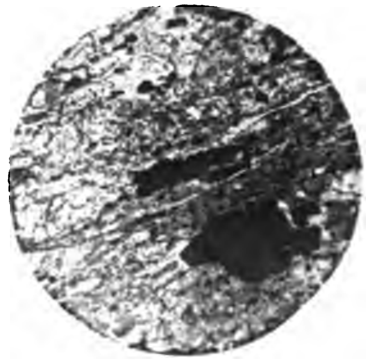
PLATE II.

Fig. 1. Micropegmatite country rock from the Ivanhoe Mine, 100-ft. level, West Cross-cut. Crossed Nicols. x 23. Slide 1238.

Fig. 2. Country rock from the hanging-wall, Boulder Main Reef. x 29. Slide 1300B. The dark patches are iron pyrites. The micro-photograph shows a streaky and—to some extent—the lenticular structure.

Fig. 3. Section of a vein (telluride-bearing) in the Kalgurli Mine. x 18. Slide 1312A. The slidé shows ilmenite with leucoxene, and, in the centre, an area of quartz grouped round a tongue-shaped intrusion of the matrix; the quartz grains in this area extinguish simultaneously. The groundmass consists of minute fragments of quartz, water-clear material, chlorite, and calcite.

1



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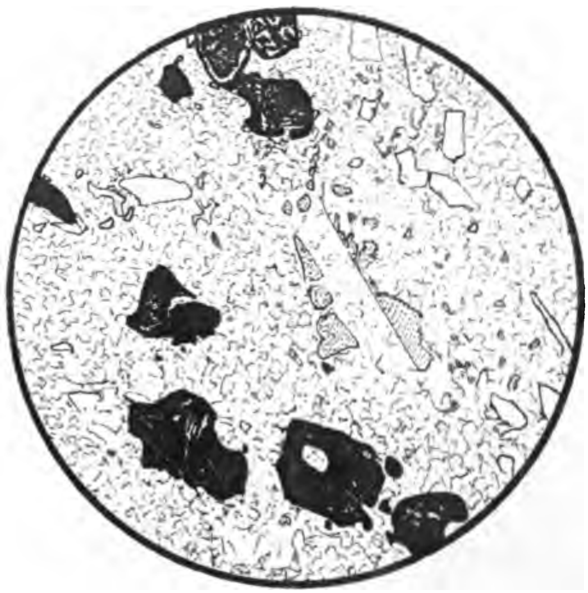

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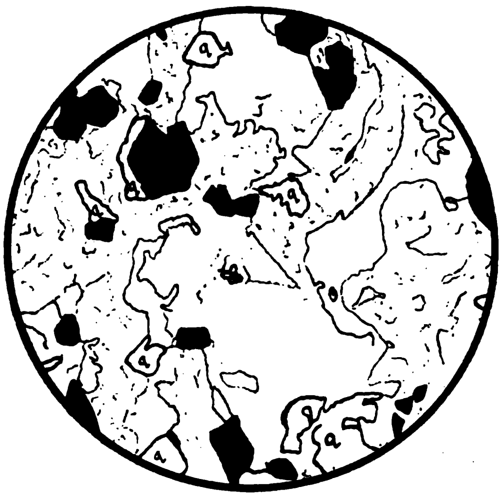
Micro-phot. and delt. G.W.C.

PLATE III.

Fig. 1. Country rock from the Australia East Lease, 140-ft. level. x 36. Slide 1200c. The section shows magnetite, ilmenite (much altered), felspar (*f*), quartz (*q*), calcite, sericitic mica. The felspar shows carlsbad and albite twinning and is undergoing replacement by calcite and white mica.

Fig. 2. Section of a vein (telluride-bearing) in the Kalgurli Mine, treated with cold dilute hydrochloric acid. x 43. Slide 1312c. The section shows titaniferous iron, quartz (*q*), chlorite, gaps caused by the removal of carbonates, and numerous small areas of quartz.

1



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G.W.C., delt.

PHOTO-LITHOGRAPHED AT THE GOVT. PRINTING OFFICE,
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PLATE IV.

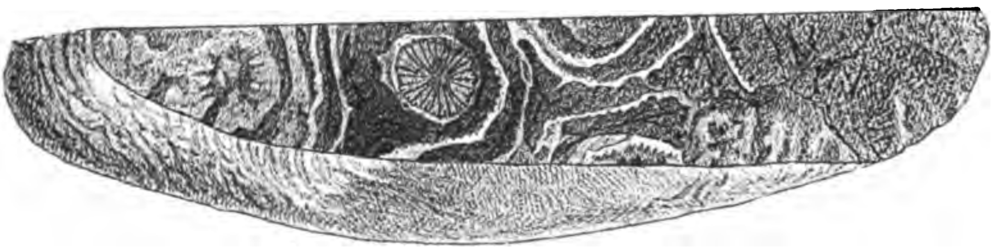
Endophyllum Schlüteri, *Eth. fil.*

Fig. 1. Vertical polished section of the corallum, showing corallites and vesicular connecting floors.

Fig. 2. Horizontal polished section, with a corallite showing the septa, and the cut edges of some of the connecting floors toothed.

Fig. 3. The two foregoing (Figs. 1 and 2) sections, seen obliquely, to show the course and continuity of the connecting floors.

1



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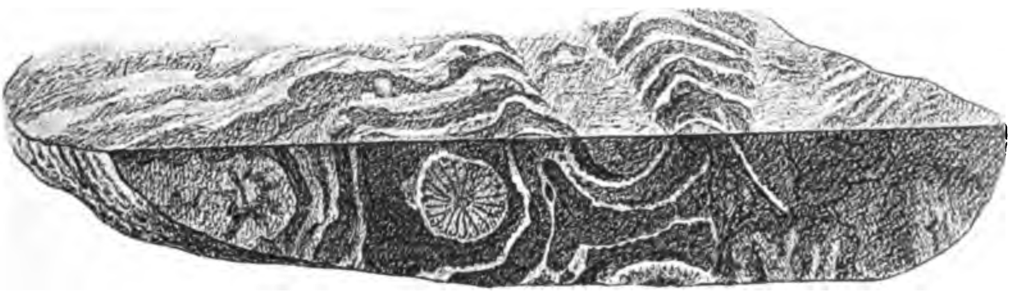

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Frank R. Leggatt, del.

PLATE V.

Endophyllum Schlüteri, *Eth. fil.*

Fig. 1. Vertical section, prepared for the microscope, of two corallites with septa, as vertical lamellæ, dissepiments, and vesicular floors.

Fig. 2. Horizontal section of a similar nature, the centre of the corallite occupied by a tabulum.

Fig. 3. Portion of Pl. IV, Fig. 1, showing the blunt tooth-like projections scattered over the thickened floors. x 3.

Fig. 4. Portion of Pl. IV, Fig. 1, showing the very close fine tabulæ occupying the centre of the corallite. x 4.

Fig. 5. Portion of a corallite, viewed horizontally to show the thickened bases of the septa suddenly tailing-off into fine hair-like lines. Greatly enlarged.

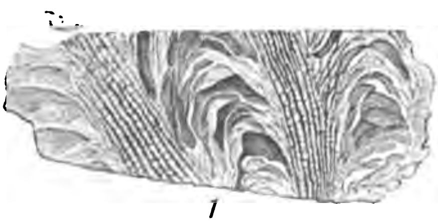

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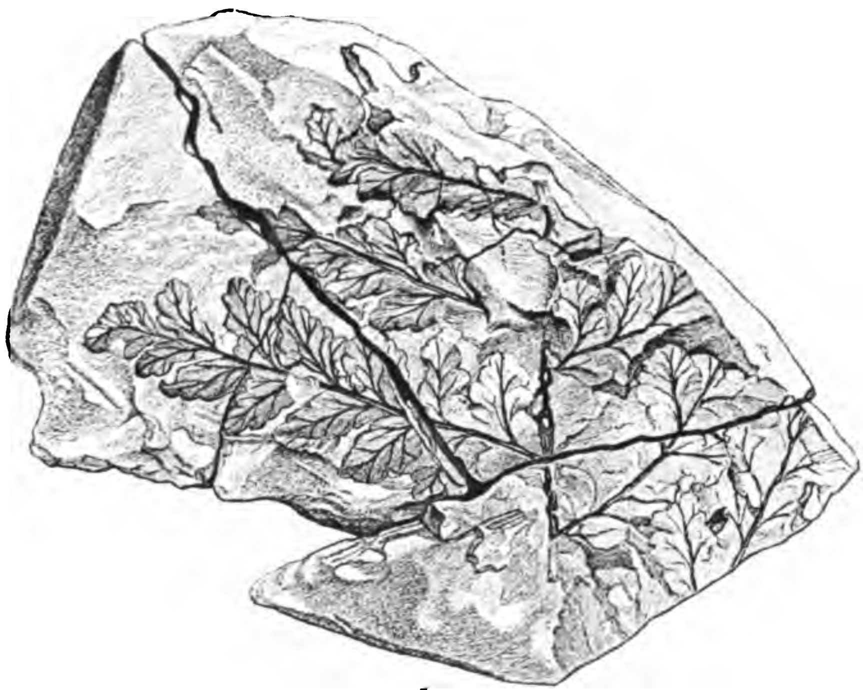
PLATE VI.

Fig. 1. *Ovopteris alata*, Brongniart, sp. From Leconfield, Greta Coal-measures.

Fig. 2. *Sphenopteris grandis*, Dun. From Denton Park, Greta Coal-measures.

Drawn from nature by Mr. F. R. Leggatt, natural size.



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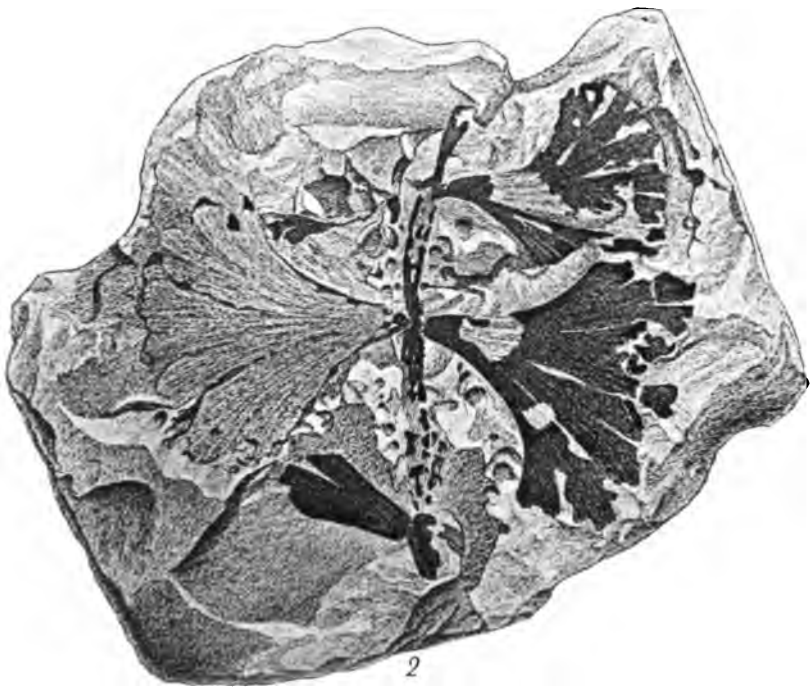

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PLATE VII.

Illustrations to accompany Dr. C. Hlawatsch's paper on Stolzite and Raspite from Broken Hill.

Reproduced by photo-lithography from the original plate.

Fig. 3.

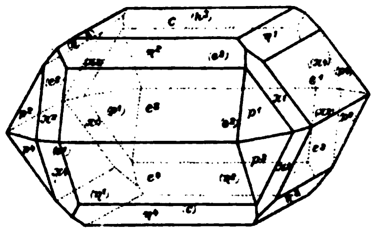


Fig. 8.

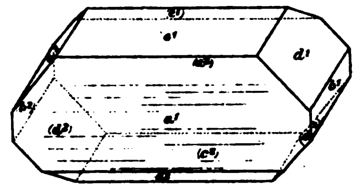


Fig. 10.

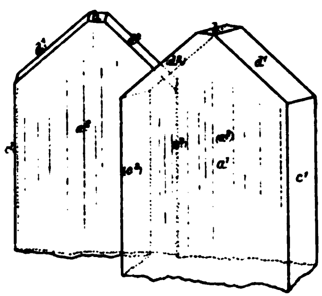


Fig. 9.

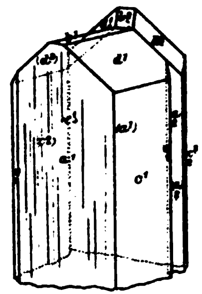


Fig. 6.

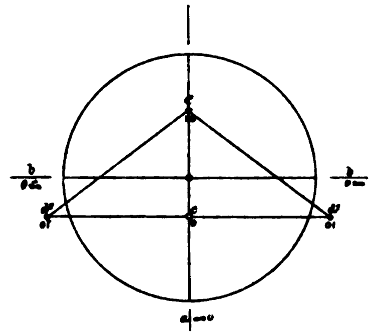


PHOTO-LITHOGRAPHED AT THE GOVT. PRINTING OFFICE, SYDNEY, NEW SOUTH WALES.

PLATE VIII.

Receptaculites australis, *Salter.*

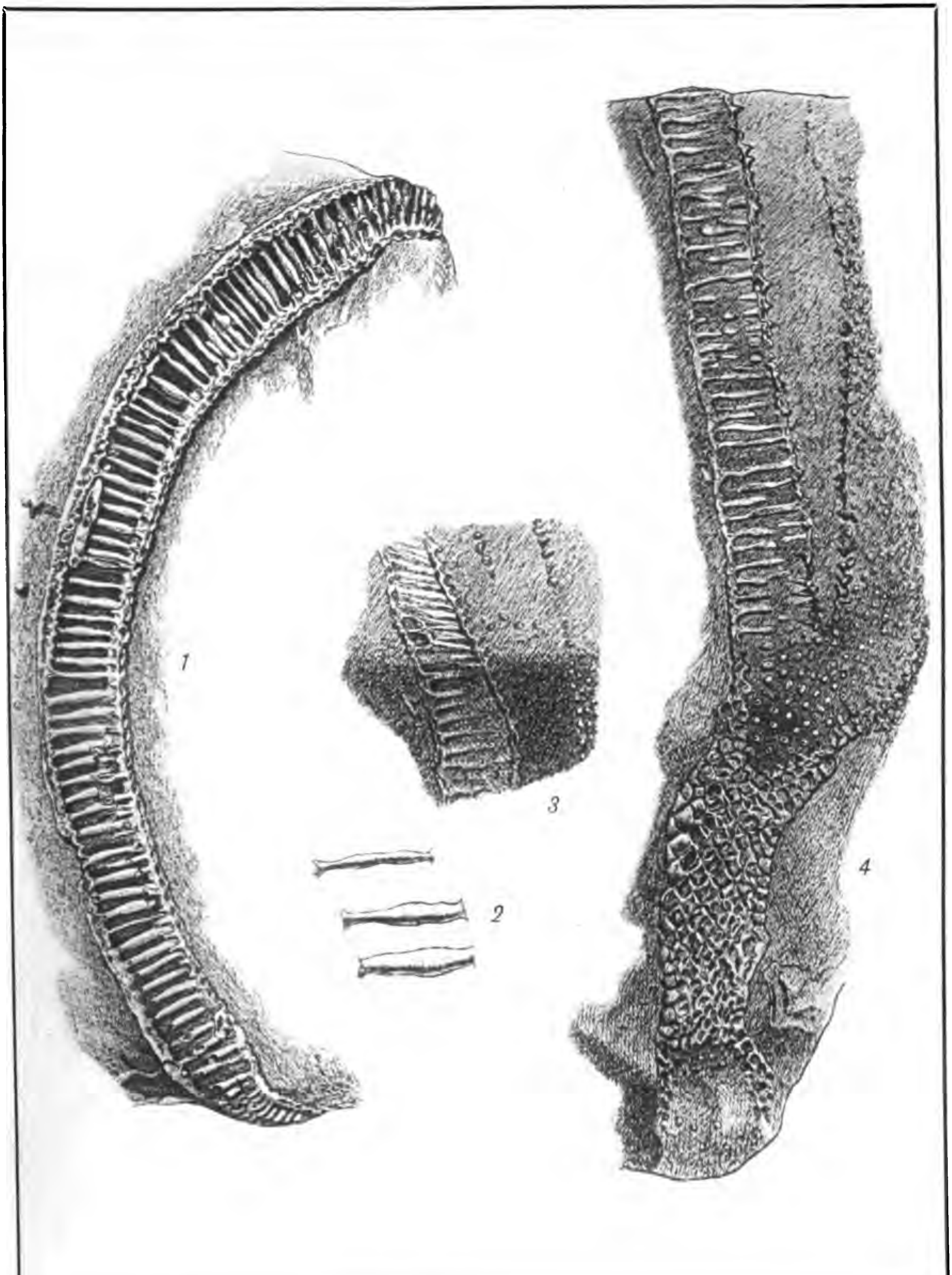
Fig. 1. Natural section of the wall, afterwards etched, showing columns. From Parish Warroo, County Murray.

Fig. 2. Three columns, isolated from Fig. 1. x 2.

Fig. 3. Portion of wall in natural section, showing the form in section and the exterior rhomboidal plates. From portion of specimen shown in Fig. 4.

Fig. 4. Portion of a large specimen, seen partly in naturally-weathered section and partly from the exterior. In the upper portion of the figure the wall on either side is shown, the intermediate convexity having been removed, thus exposing a portion of the internal cavity. In the lower part the rhomboidal plates are visible. The form of this individual was evidently more or less sack-like. From Parish Warroo, County Murray.

Drawn from nature by Mr. F. R. Leggatt.



Frank R. Leggatt, del.

PLATE IX.

Receptaculites australis, *Salter.*

Fig. 1. Portion of a specimen, showing the wall, partly in vertical section and partly in horizontal; in the latter the columns are cut across, and are of varying diameter. From Parish Warroo, County Murray.

Fig. 2. Portion of wall in vertical section, showing the columns, rhomboidal plates (?), and portions of the pediments. From Tarago. x 2.

Fig. 3. Transverse section, showing circular outline. This individual was probably more or less disc-shaped. From (Humewood ?) Yass District. Reduced ½.

Fig. 4. Internal view of an apical (?) portion of a small individual, showing the columns in section with portions of tangential rays attached, and round the margins the latter without the columns affixed to them. From Parish Warroo, County Murray.

Fig. 5. Portion of Fig. 4, enlarged twice, showing similar features.

Fig. 6. Portion of Fig. 4, enlarged to show dovetailing and overlapping of the tangential rays. x 2.

Fig. 7. Portion of Fig. 4, enlarged to show some of the preceding characters and punctures by weathering on the under surface of the rhomboidal plates. x 2.

Fig. 8. Micro section of rhomboidal plates, showing the grooves separating them, and traces of tangential rays beneath them.

Fig. 9. Micro section of a portion of a wall, showing the variable form of the columns, portions of the pediments, and the fused tangential rays with rhomboidal plates of the outer surface (along the upper line of the section). The tangential rays are distinctly shown in this section as circular apertures, but have not been distinctly portrayed by the Artist. x 2. From Parish Warroo, County Murray.

Fig. 10. Micro section, showing the same characters as Fig 9, but in a less fused condition. From Parish Warroo, County Murray. x 2.

Drawn from nature by Mr. F. R. Leggatt.

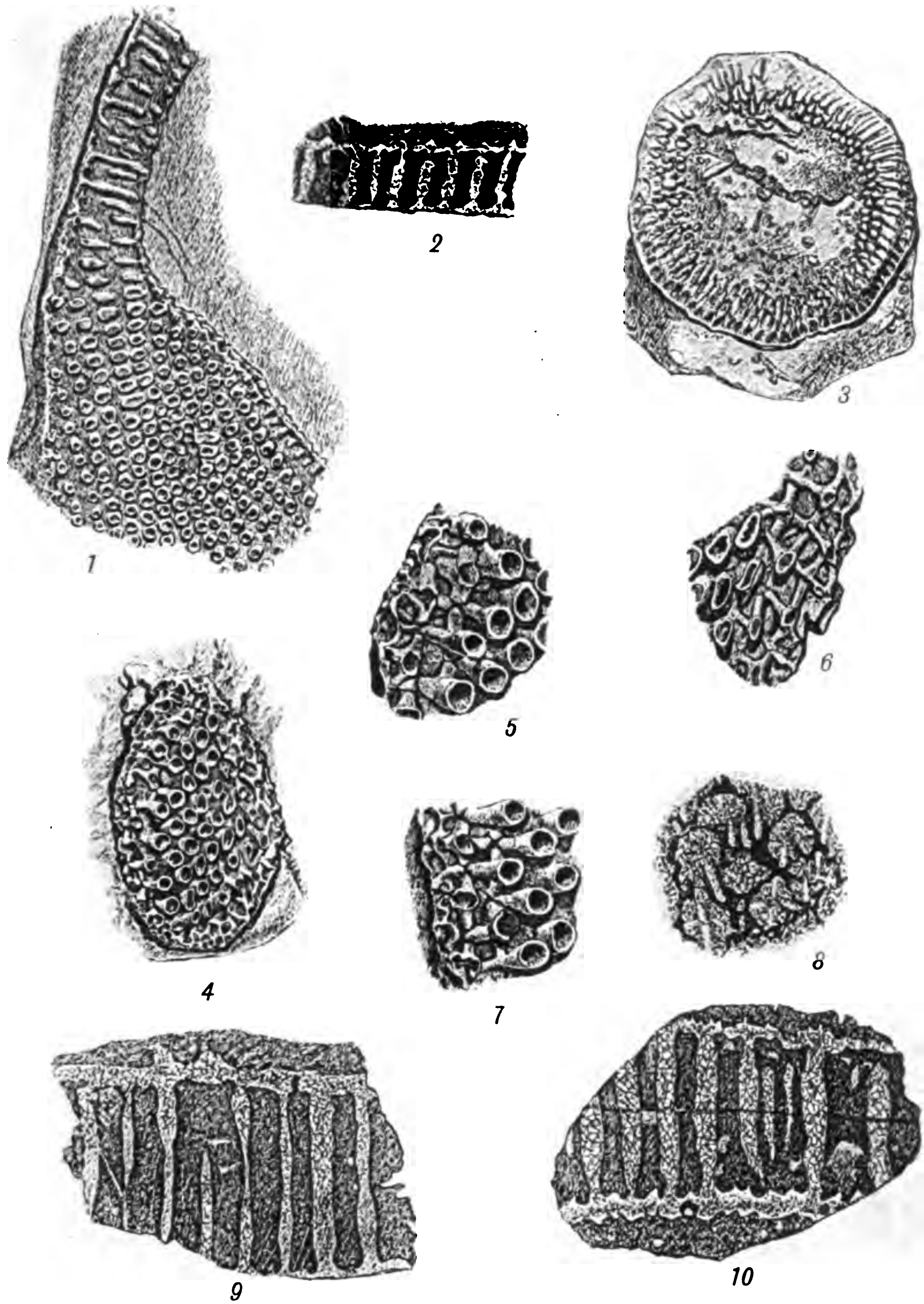


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PLATE X.

Receptaculites australis, *Salter*.

Fig. 1. Polished section of a form similar to Pl. X, Fig. 3, showing the columns in transverse section and their engine-rolled arrangement. From Humewood (?), Yass District.

Fig. 2. Portion of weathered specimen, showing part of a wall and the interior rhomboidal plates. The impressed grooves between the plates and the pores at their angles are distinctly visible. From Parish Cavan, County Cowley.

Fig. 3. A similar but different specimen (reversed). The upper surface, here the bottom, exhibits the rhomboidal plates and the tangential rays united; the lower surface, here the top, the columns united by their pediments to the interior rhomboidal plates. From Parish Cavan, County Cowley.

Fig. 4. Weathered fragment of the interior rhomboidal plates, showing the impressions of the rhomboidal plates and the infilled separating grooves between them. From Tarago.

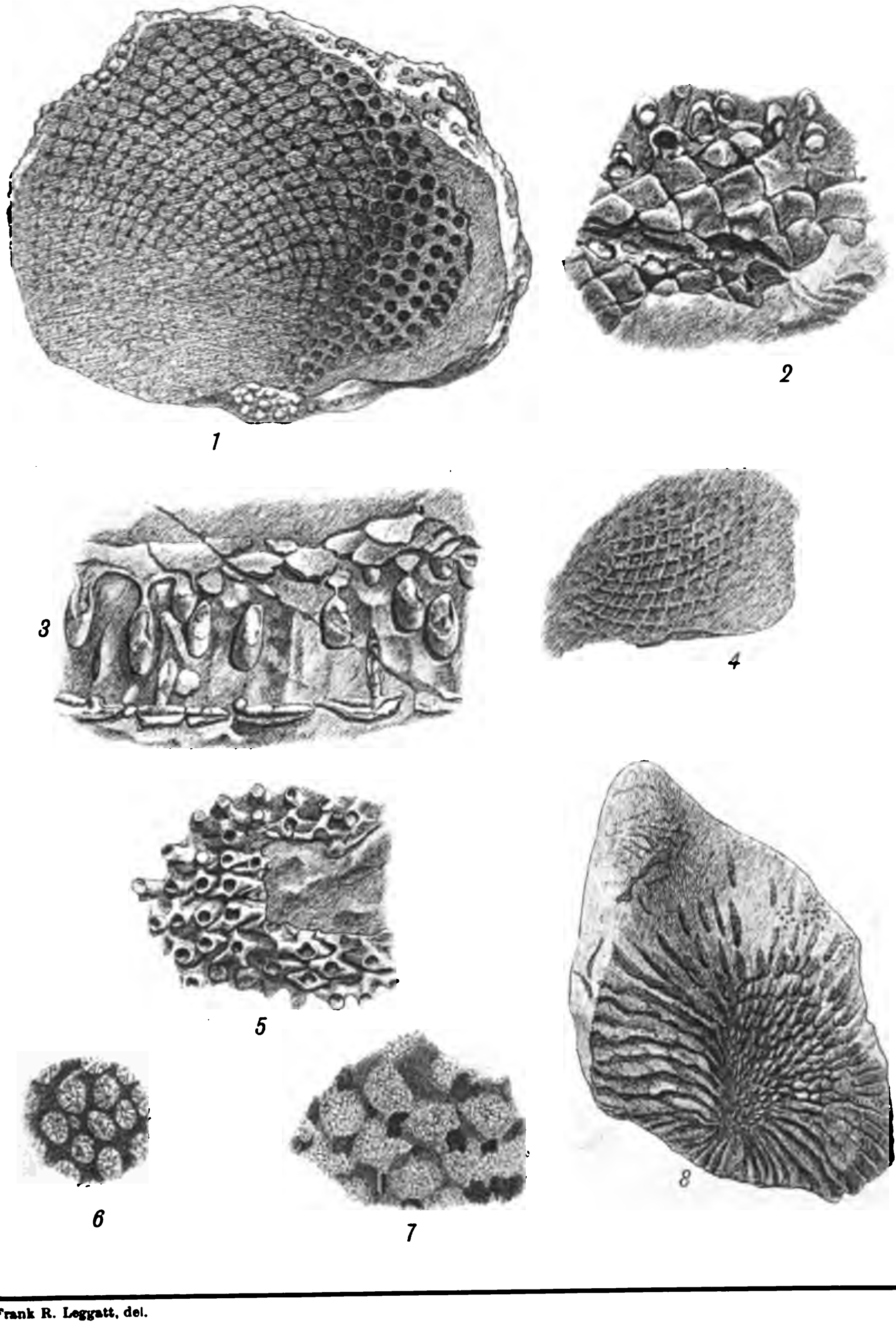
Fig. 5. Weathered specimen, seen from the inside, showing the uppermost portions of the columns attached to the rays and the peculiar dovetailing of the latter. From Goodradigbee.

Fig. 6. Microscopic cross section, showing crystalline structure of the infilling material. From Parish Warroo, County Murray. x 2.

Fig. 7. Micro section of the internal rhomboidal plates, showing the pores at the angles, much enlarged by disintegration.. From Parish Warroo, County Murray. x 3.

Fig. 8. Apical portion of an individual, showing a nucleus and the columns radiating therefrom. From Humewood (?), Yass District.

Drawn from nature by Mr. F. R. Leggatt.



Frank R. Leggatt, del.

DEPARTMENT OF MINES AND AGRICULTURE, SYDNEY.

RECORDS

OF THE

GEOLOGICAL SURVEY OF NEW SOUTH WALES.

Vol. VI.] April, 1899. [Part 2.

VII.—On the alleged evidence of glacial action in the Permo-Carboniferous Rocks of the Ashford Coal-field: by Professor T. W. E. David, B.A., F.G.S., and E. F. Pittman, A.R.S.M., Government Geologist.

Two reports on the geology of the Ashford Coal-field have previously been written by us; the first of these appeared in the Annual Report of the Department of Mines.*

The second was published in the Records of the Geological Survey of New South Wales.†

Reference has also been made ‡ to the strong unconformity between the Permo-Carboniferous Coal-Measures at Ashford, and the underlying Carboniferous (Gympie) series.

The reason for our present further reference to the geology of the Ashford Coal-field, is the publication of a paper read by Mr. E. J. Dunn, F.G.S., before the Royal Society of Victoria, on the 9th December, 1897.§

In this paper Mr. Dunn states that he has discovered an extension of what he terms the Derrinal conglomerate at Fraser's Creek Station, near Ashford, and also as far north as Cherry Gully and Silverwood, between Stanthorpe and Warwick, in Queensland. He alleges that—" At Fraser's Creek Homestead, granite outcrops

* Ann. Rept. Dept. Mines N.S. Wales for 1885 [1886], p. 139.
† Records Geol. Survey N.S. Wales, 1896, v, Pt. 1, p. 26.
‡ Procs. Linn. Soc. N.S. Wales, 1893, viii (2), p. 586.
§ Procs. R. Soc. Victoria, 1897, X (new series), Pt. II, p. 204.

on the west side of the river Severn, and strewn over this are numerous pebbles and boulders of many varieties of porphyry, granite, &c., derived from the glacial conglomerate which has been denuded at this site. Scratched surfaces are plentiful, and the variety of pebbles, unlike any in place within the present watershed, are characteristic of the Derrinal conglomerate. The hard porphyry boulders have retained the scratches best of all; a specimen of them is exhibited. About two miles south from the homestead is Coal Gully. . . . On the upturned edges of these Carboniferous (?) rocks, the Derrinal conglomerate was laid down, and then succeeded, in a conformable manner to the Derrinal conglomerate, black shales, grey shales, a coal seam, then thick-bedded sandstones, &c."

After referring to the occurrence of *Gangamopteris*, which had already been noted by us in the shales associated with the twenty-seven feet coal seam at the above locality, Mr. Dunn states: "The Derrinal conglomerate and conformable overlying shales, coal, &c., all dip westward at about 56°."

Mr. Dunn then proceeds to comment on our previous reports on this coal-field, and states that "the interesting nature of the conglomerate associated with it appears to have escaped notice."

Later on Mr. Dunn remarks: "The Ashford Coal-measures undoubtedly represent the lowest horizon of coal-bearing beds in New South Wales on the Greta Coal-Measures. . . . There is, about half a mile south of Coal Gully, another small gully running east into the Severn River, called Sheepskin Gully. About one quarter of a mile from the river up the gully, the Derrinal conglomerate occurs, resting unconformably upon the upturned edges of the Carboniferous (?) beds; these latter dip E. 66°, while the glacial conglomerate dips W. 26°. At this point the conglomerate consists of small pebbles, having characteristic glaciated forms, some showing striations. . . . An immense area of Derrinal conglomerate must have been denuded to supply the great pebble beaches along the Severn River with material so unlike any rocks now existing within its present watershed. In Queensland the Derrinal conglomerate is well shown, resting on granite at Cherry Gully Railway Station, 187 miles south of Brisbane; it is observable in the cuttings along the line for over a mile in length. The pebbles, where weathered out, are of the usual glacial character, and of many varieties of rocks; some show distinct scratches. The matrix is granitic detritus. At Silverwood Railway Station, 179 miles from Brisbane, nearly horizontal glacial conglomerate rests on the upturned edges of the much contorted Carboniferous (?) beds. Here the pebbles are of a great variety of rocks, glaciated in form, and in some cases polished and scratched. . . There is the very practical fact that the Derrinal conglomerate forms the floor of all our valuable coal-seams, and, what is almost as important in this droughty land, also the floor of the strata from which artesian water is obtainable."

Upon reading Mr. Dunn's paper, as published in the Proceedings of the Royal Society of Victoria, we determined to revisit the locality in company, as on our previous separate examinations of the coal-field we had certainly not noticed any evidence of glaciation in the conglomerates. The following are the chief results (so far as they relate to Mr. Dunn's statements) of our investigation, which was made last June (1898):—

The pebbles referred to by Mr. Dunn as showing evidence of glacial action belong to three totally distinct geological horizons, viz., (*a*) Post Tertiary, (*b*) Triassic, and (*c*) Permo-Carboniferous.

(*a*) We first visited the bank of the Severn, close to the Fraser's Creek homestead, at the spot where Mr. Dunn obtained his specimens of so-called glaciated pebbles. This spot was pointed out to us by Mr. Fletcher, who was with Mr. Dunn at the time the latter visited the locality. It is situated a short distance back from the left bank of the Severn River, in a small gully which intersects the alluvial plain formed by the flood waters. We made a careful examination of a large number of the pebbles, which vary in size from less than an inch to more than a foot in diameter, and utterly failed to find any trace on them of glacial markings, in the way of either polishing, grooving, striation, or faceting. On our return to Sydney, having heard that Mr. H. G. Stokes, Manager of the Silver Spur Mine, Texas, had accompanied Mr. Dunn to Ashford, and had in his possession some of the pebbles collected by that gentlemen, and considered by him to be typical examples of the so-called glaciated blocks, we wrote and asked him whether he would kindly allow us to inspect them. Mr. Stokes courteously forwarded two of these pebbles, which are now in our possession. They exhibit very faint and irregular scratches, which we have no hesitation in saying are not of glacial origin. They are entirely different in character from the true glacial markings which form so conspicuous a feature in the case of the boulders and pebbles in the Bacchus Marsh and Derrinal beds of Victoria, and the Hallett's Cove and Inman beds in South Australia. They are also quite unlike any of the markings on the glaciated pebbles of the Boulder Beds formed during the great ice age in Great Britain. We therefore entirely disagree with Mr. Dunn's statement that these pebbles show glacial markings. Moreover, we were unable to find a single pebble which could not be recognised as similar in lithological characters to some rock known to us within the present watershed of the Severn River above Fraser's Creek Station. We dissent, therefore, from the opinion expressed by Mr. Dunn that these pebbles are foreign to the district.

(*c*) We next proceeded to examine the outcrops of the Permo-Carboniferous conglomerate in "Sheepskin" and "Coal" Gullies,—the localities referred to in Mr. Dunn's paper.

This conglomerate forms the basal bed of the Permo-Carboniferous system. It rests, with strong unconformity, on highly inclined claystones of Carboniferous (Gympie) age, and is overlaid successively by shales containing *Gangamopteris*, a coal-seam twenty-seven feet thick, also containing *Gangamopteris*, and beds of sandstone containing *Glossopteris*. In point of size the pebbles in these basal conglomerates are distinctly smaller than those seen in the Post Tertiary alluvials at the locality last described; their general size is from one to three inches in diameter, though occasional specimens reach a diameter of six inches. It is, therefore, highly improbable that the larger pebbles in the bank of the Severn were derived to any great extent, from the re-distribution of the Permo-Carboniferous conglomerate.

This conglomerate is of a pale greenish-grey colour at a depth, weathering reddish brown at the surface. In this respect it has a general resemblance to the typical conglomerates of the Permo-Carboniferous Beds in the Newcastle district (N. S. Wales), and the latter, as is well known, have also a general resemblance to the water-worn conglomerates associated with the glacial beds at Bacchus Marsh, Derrinal, &c., Victoria.

The pebbles in the Ashford conglomerate consist of felspathic quartzites and claystones, derived from the Gympie beds, with a few of chalcedonic quartz, and, rarely, fragments of a much decomposed rock resembling aplitic granite. They are mostly, if not entirely, of local origin; and here, again, we are unable to agree with Mr. Dunn's conclusion that the pebbles are derived from rocks foreign to the district.

After a careful search we were unable to discover the least trace of glacial action in these beds.*

(*b*) At Cherry Gully and Silverwood, in Queensland, the conglomerate referred to by Mr. Dunn forms, in our opinion, the basal bed of the Triassic System, and would thus be on a totally different horizon from the Ashford conglomerate, although both have been described by Mr. Dunn as identical with the Derrinal conglomerate.

Here, again, the pebbles are distinctly of local origin, and not foreign to the district, as Mr. Dunn has stated. They consist of claystone, lydian stone,

* Since this paper was written discoveries have been made of glaciated blocks in the Lower Marine as well as in the Upper Marine beds of the Permo-Carboniferous System in New South Wales. Mr. W. G. Woolnough found, last January, in the Upper Marine beds near Branxton a beautiful example of a glacially striated and polished pebble; and at the beginning of this month one of us (Professor David) and Mr. E. C. Andrews, B.A., found fourteen glacially grooved and striated boulders in the basal bed of the Lower Marine Series, about one mile N.E. from Lochinvar bridge, Maitland. While these discoveries confirm the views of the late Government Geologist, C. S. Wilkinson, that the Greta Coal Measures are sandwiched between formations partly of glacial origin, they do not alter our contention that, so far as our observations extend, the Permo-Carboniferous basal beds at Ashford do not exhibit glacial markings.

We admit, however, the strong probability (admitted for many years past by geologists in New South Wales and elsewhere) that the Greta conglomerates were deposited at the time intermediate between the dates of the formation of the erratic beds above and below the Greta, and that they were therefore contemporaneous with part of the great Permo-Carboniferous Ice Age of the Southern Hemisphere.

quartz, shale, felspar porphyry, and granite. We utterly failed to find any trace in them of glacial markings. The conglomerate, however, is probably homotaxial with the beds at the Boggo Gaol road, Brisbane, and the latter beds contain large blocks of cherty claystone (Gympie) which, as Mr. R. L. Jack has pointed out, may be glacial erratics. No glacial markings, however, have as yet been noticed on these blocks at Brisbane.

In reference to the age of the granite in relation to that of the Permo-Carboniferous rocks at Ashford, Mr. Dunn states: "The granite is older than the conglomerate, as proved at Cherry Gully Railway Station, Queensland."

There can be no doubt whatever that the granite at Cherry Gully is older than the overlying sedimentary rocks; but as the latter are almost certainly on a higher (Mesozoic) horizon than the Ashford conglomerates, which are of Palæozoic age, their junction with the Cherry Gully granite throws no light on the question as to the relative ages of the Ashford granite and the Permo-Carboniferous rocks associated with it.

The foregoing remarks relate to questions raised in Mr. Dunn's paper in the Proceedings of the Royal Society of Victoria. In a future issue we hope to record some further observations on the Ashford Coal-field, and particularly as to the relationship between the granite and the Permo-Carboniferous rocks.

VIII.—Note on the Geology of the Hill End Gold-field: by E. F. PITTMAN, A.R.S.M., Government Geologist.

IN the year 1879, when occupying the position of Geological Surveyor under the late Mr. C. S. Wilkinson, F.G.S., I made a geological survey of the Hill End Gold-field.*

One of the characteristics features of the field was a rock of a rather fine-grained and crystalline character. Its chief constituents appeared to be quartz and felspar, but it was exceedingly difficult to classify. At first sight it seemed in places to be unquestionably of igneous origin; on the other hand it appeared to be distinctly bedded. It was found to be fossiliferous in places, and it occasionally contains numerous water-worn pebbles (some of considerable size) enclosed in its crystalline matrix. After consultation with Mr. Wilkinson, I described the rock as a metamorphosed conglomerate, and suggested that its alteration had been brought about by heat and pressure due to dynamical forces.†

* Ann. Rept. Dept. Mines N. S. Wales for 1879 [1880], map, and notes to accompany map.

† *Vide* also Ann. Rept. Dept. Mines N. S. Wales for 1879 [1880], p. 213.

In a paper read before the Royal Society of New South Wales on the 4th November, 1896,* Professor David described some granitic sills which he had recognised as intruding a series of Radiolarian claystones at Tamworth, and some diorite sills at the Junction Mines, Mandurama, and he stated his conviction that the Hill End rock above referred to (and of which he had only seen hand specimens) was a similar occurrence to the Tamworth and Mandurama rocks, or, in other words, that it formed intrusive sills. (A subsequent examination, however, by Professor David and myself convinced us that the supposed sills at Tamworth really consist of tuffs.)

After having spent some time, in conjunction with Professor David, in studying the Tamworth section, I have recently revisited Hill End after an interval of nearly twenty years, and I must now frankly confess that the conclusions I had previously formed, as to the genesis of the Hill End rock, were erroneous.

In view of the light thrown upon the Hill End section by my recent study of the geology of Tamworth, I have now no doubt that some of the rocks at the former place are intrusive. Narrow beds of slate are seen to alternate with what appear to be sills of a more or less fine-grained quartz porphyry, and veins of the latter can occasionally be seen crossing and intruding the former.

Some of the rocks, as already stated, contain numerous water-worn pebbles, chiefly of quartzite, and perfectly distinct and fairly well-preserved crinoids, as well as less distinct remains of other marine fossils, are fairly abundant. In view of the fact that the pebbles and fossils are completely imbedded in a matrix of igneous character, it is reasonable to attribute a tuffaceous origin to these beds. Moreover, some of the non-fossiliferous rocks, which have all the appearance of quartz porphyries when examined microscopically, show evidence of tuffaceous origin under the microscope. On the other hand, it appears probable that some of the intrusive rocks occur as sills, and that they have been subjected to much crushing and chemical alteration.

The exact relationship of the different members of the series to one another can only be determined by more detailed observations, accompanied by systematic microscopical examinations of thin sections.

* Journ. R. Soc. N. S. Wales for 1896 [1897], XXX, pp. 286, 287.

IX.—Further Remarks on the Saddle Reefs of the Hargraves Gold-field: by J. ALEX. WATT, M.A., B.Sc., Geological Surveyor.

Plates XI–XIV.

A FEW months ago, while on a brief visit to Hargraves, my attention was drawn to the fact that some of the reefs occurring in the vicinity of that township resembled in their essential features the famous Saddle Reefs of the Bendigo Gold-field in Victoria. The few notes made during that hurried examination were embodied in a short paper, and printed in a former number of these Records,* where previous references to these reefs are recorded.†

A second visit gave me an opportunity of examining a little more carefully these interesting reefs. The additional information thus gained is now presented; and although still very incomplete, it is hoped that sufficient data have been obtained to establish their true nature. It must be recognised, however, that a thorough examination of the Hargraves District, necessitating the spending of several months in field-work, could not fail to bring to light facts, not only of very great scientific interest, but also of great value and assistance to those engaged in mining pursuits in that neighbourhood.

Contents.

I.—Introduction.

Hargraves, in the early days of mining in this Colony, was one of our richest "alluvial fields," where the alluvial deposits were shallow and yielded large quantities of gold.

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* Records Geol. Survey N. S. Wales, 1898, V, pt. 4, pp. 153–160.

† NOTE.—Since writing this paper my attention has been drawn to a description of these reefs by Mr. Seaver, published some years ago (Journ. R. Soc. N. S. Wales for 1887, XXI, pt. 1, pp. 136–138). More recently they have been referred to by Herr Schmeisser in his work "Die Goldfelder Australasiens," p. 69 (Berlin, 1897) of which a translation by Professor Louis has just been published.

The reefs have received at different times a great deal of attention. Some, like the Big Nugget, Alma, and Eureka Reefs, were worked many years ago very profitably to a depth of about one hundred feet; but the great majority of the reefs in the Hargraves district have not been followed down below sixty or seventy feet from the surface. Down to that level most of them have produced quartz of a payable grade, while some have yielded very rich stone; but at or near the sixty-foot level the water becomes troublesome, and the individual reefs become usually too small or too poor to be profitably worked by miners, who are unable to erect suitable machinery to remove the water and to systematically prospect the ground. The mines were consequently generally abandoned when the workings reached that depth.

A noticeable feature of the reefs of this district is the rapid way in which they taper off and gradually pinch out as they are followed down. As an example of this peculiarity, we may mention the Big Nugget Reef, which is six feet thick in its upper part, or cap, and at a depth of one hundred and fifty feet from the surface is not more than a few inches.

This feature is readily explicable when the true nature of the reefs and the genetic relation that exists between them and the folding of the rocks are understood.

It is not surprising that the pinching out of reef after reef, when followed to only comparatively shallow depths, should have caused miners accustomed to exploit fissure reefs to condemn this gold-field. They did not recognise the fact that what was being worked was, in most cases, a "leg" of a saddle reef, which, by its very nature, was sure to pinch out at no great distance from the surface. And further, it was not known that by prospecting vertically between the two denuded legs a descending series of saddle reefs would in all probability be proved to exist.

This has been proved by comparatively recent mining operations, which have shown that true saddle reefs occur there, one beneath the other, between the surface and a depth of seventy feet.

It is hoped that the following description of the Hargraves Gold-field will show how similar it is, in its main features, to the Bendigo Gold-field, and thus enable the important conclusion to be drawn that the permanency of the former gold-field depends, not on the persistence in depth of the individual reefs, but on the downward continuation of the series.

While the individual reefs will, therefore, probably be found to extend not more than from one to two hundred feet below their caps, there is every reason to believe that the series will go down to very much greater depths.

II.—General Geological Features.

The Hargraves Gold-field is situated within an extensive area of strongly folded sedimentary rocks, at an elevation of between 3,000 and 4,000 feet above sea-level.

In the neighbourhood of Hargraves the sedimentary strata consist, for the most part, of slates. These vary much in colour, being most commonly bluish-grey or bluish-black, where unweathered, and occasionally greenish-brown. The slates have been intruded by dykes of a granitic rock, while bands of somewhat similar material, very numerous in places, lie parallel with the bedding planes of the slates, along which they appear to have been intruded. These latter are probably intrusive sills, and occur with great frequency on the east side of Hargraves.

(*a*) *Sedimentary Rocks.*—The sedimentary strata consist very largely of argillaceous rocks, chiefly slates, which have been considerably metamorphosed, as a result of the intense lateral pressure to which they have been subjected. They also exhibit evidences of alteration near their contact with the igneous material of the dykes and sills.

The planes of stratification of the slates are generally obscure, and are usually only to be identified by the differences in the colour of adjoining beds.

Cleavage is highly developed; the planes are usually highly inclined, and in most places have obliterated all traces of the bedding-planes. Very little evidence is available as to the age of the slates. On the grounds of their lithological characters and general structural features they may be either Upper Silurian or Siluro-Devonian.

The only Palæontological evidence is that furnished by the presence of obscure casts of corals and stem ossicles of encrinites, &c., in the so-called "dyke." (Pl. XI.) This is a band of rock about twenty feet in width, which occurs on the west side of Hargraves, and can be followed for at least two miles along its strike, which corresponds with the trend of the enclosing sedimentary strata.

This rock, where cut in the western crosscut from the Eureka Deep Shaft which is 240 feet in depth, consists largely of igneous matter, in which crystals of quartz and felspar can be readily identified. In this are embedded pebbles of quartz whose water-worn character is apparent. In addition to these are fragments of slate, usually angular, which present every appearance of having been torn off from the surrounding beds.

A very remarkable feature about this so-called "dyke" is the presence of obscure casts of fossils, chiefly corals and encrinite stems. But where it crosses

Louisa Ponds Creek it is so full of water-worn pebbles as to be distinctly conglomeratic in character; but even there igneous material is present, separating the pebbles from one another.

The intimate association of igneous and sedimentary materials which this rock presents naturally suggests a tuffaceous origin. This suggestion might seem to be supported by the presence of the fossil casts.

But the intrusive character of the igneous material of the "dyke" seems so clear that a more probable explanation of the phenomena is to consider the "dyke" as a fossiliferous bed of grit and conglomerate, which has been intruded by molten matter. The preservation of fossils under such circumstances is very remarkable.

(*b*) *Igneous Rocks.*—The intrusive rock that forms the dykes is of granitic composition. In it crystals of quartz and felspar can be readily made out, which in microscopic sections are seen to be embedded in a granular mass of the same mineral composition. A large dyke of this rock, nearly half a mile wide, occurs about a mile to the east of the township of Hargraves. Its trend is roughly parallel to the strike of the slates, viz.,—N. 20° W. and S. 20° E.

On each side of this dyke-mass, the slates, which are very much altered and disturbed, are separated by numerous bands of igneous material. These bands present every appearance of lying comformably with the slates—that is, of being parallel to their bedding planes. There is thus a series of rocks consisting of beds of slate alternating with intrusive sills of igneous matter. These sills appear to be thickest in the vicinity of the dyke.

The rocks throughout the district are highly tilted with an average dip of from 60° to 70°. It is very noticeable that the sills are very numerous, and of large proportions in the neighbourhood of the dyke, but become fewer in number and much thinner as they are traced westwards away from the dyke.

Thus, at Tucker's Hill, the folded rocks which are contiguous to the dyke (Pl. XII), and which enclose saddle reefs, consist largely of thick intrusive sills; while at Hargraves, where the folds are situated at some distance from the dyke, the sills are few in number and comparatively thin.

The texture of the sills varies very much, being coarse-grained and granitic in the larger sills adjoining the dyke, and fine-grained and felsitic in the smaller sills.

The character of the junction-planes between the slates and the sills, the occasional intrusion of the sills across the bedding planes of the slate, and the presence of pieces of slate, sometimes angular at others subangular, embedded in the substance of the compact sill-rock, leave little room for doubt as to the

intrusive character of the bands of igneous rock. As these lie along or parallel to the bedding planes of the sedimentary strata they are known as sills. The opaque white colour of the outcrops of the small sills at Hargraves contrasts strongly with the yellow or brown colour of the slates, and thus are easily distinguished from them.

(*c*) *General Structure.*—On each side of the granite dyke the slates and enclosed sills have been thrown into a series of folds. (Pl. XII.)

The participation of the sills in the folding to which the slates have been subjected proves that their intrusion took place previous to the folding.

While the beds of shale, now converted into slates by lateral compression, were still horizontal, or it may be in the initial stages of the folding, the intrusion of the igneous mattter of the dykes probably took place, and was accompanied by extensive injection of the molten material between the bedding planes of the shales. This latter operation would be materially assisted by lateral compression, which would have the tendency to separate the beds of shale from one another, thus granting ready access to the sill-matter.

Mr. F. G. Balkley* has similarly invoked the agency of lateral compression in assisting to account for the extensive development of intrusive sheets or sills at Leadville, Colorado. These sills, which have been described by Mr. S. F. Emmons,† vary in thickness from a foot or two up to over a thousand feet, and individual sheets can be traced laterally for many miles.

Similar developments of intrusive sheets or sills have been described by Prof. David at Mandurama, in this Colony.‡

At Mandurama they occur interstratified with claystones, and were originally called laccolites. They are gold-bearing, their upper decomposed portions having been largely worked for that metal.

Below the zone of decomposition the sills consist of a hard, blue, highly calcareous rock, which appears to have been originally of a dioritic or andesitic character.

Irregular masses of arsenical pyrites, sometimes carrying as much as ten or twenty ounces of gold per ton, occur in the undecomposed portions of the sills. These may be magmatic segregations from the eruptive matter of the sills.

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* The Separation of Strata in Folding. Trans. Am. Inst. Min. Eng., xiii, p. 384.

† Geology and Mining Industry of Leadville, Colorado. Mon. U.S. Geol. Survey, xii, p. 295.

‡ Note on the Laccolites of the Junction Mine, near Mandurama. Proc. Linn. Soc. N.S. Wales, 1890, V, 2nd series, p. 421.

The accompanying diagrammatic drawings are intended to illustrate my reading of the development of the general structure in the Hargraves District.

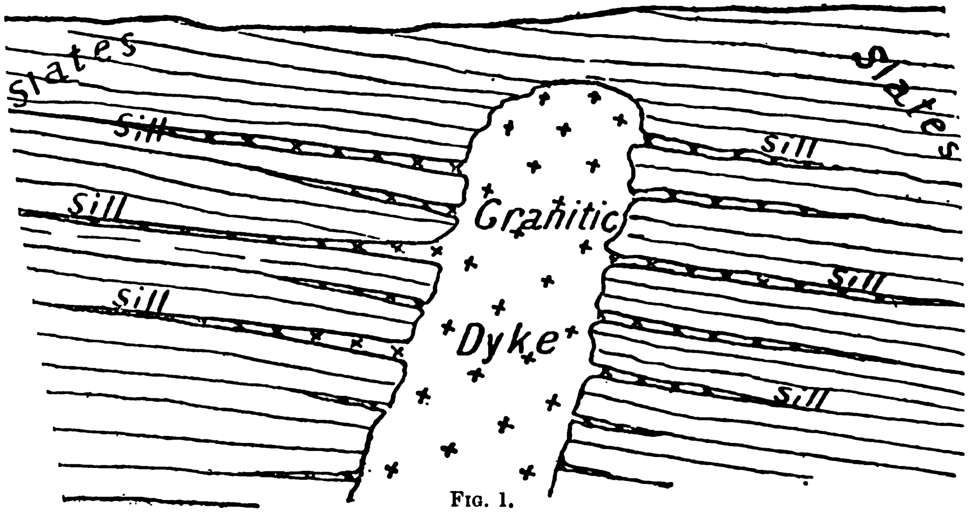


FIG. 1.

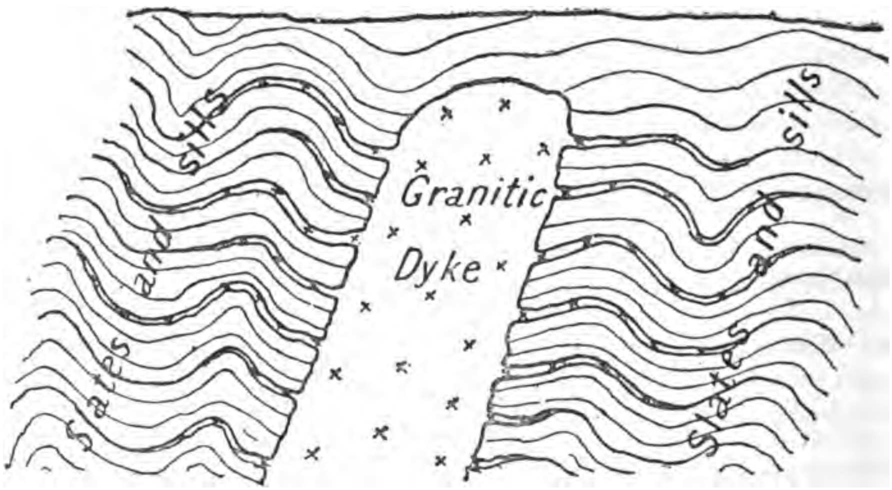


FIG. 2.

Fig. 1 represents the beds of shale, before the sharp folding has taken place, across which the granitic dyke has broken, and along the bedding planes of which sills have been intruded. Fig. 2 indicates the condition of things after folding.

The folds follow one another at Hargraves so rapidly that five occur within a distance of ten chains, measured at right-angles to the strike.

The arching over of the strata can be very clearly seen on some parts of the surface where the soil and subsoil have been removed.

Plate XIII is a reproduction of a photograph taken for the purpose of showing the bending over of the strata in the centre-country of an arch. The centre of the

arch or centre-country is indicated by ①. This is the position occupied by the saddle of the reefs, although in this particular place none are showing. On each side the rocks dip away from it to the east and west, forming, respectively, the east and west country. It is there that the east and west legs of the saddle reefs are found.

Faults appear to be of rather common occurrence, but, as a rule, their throw is small. Reversed faulting, which is more frequent than normal faulting, would seem to have accompanied the final stages of folding. The accompanying section, Fig. 3,

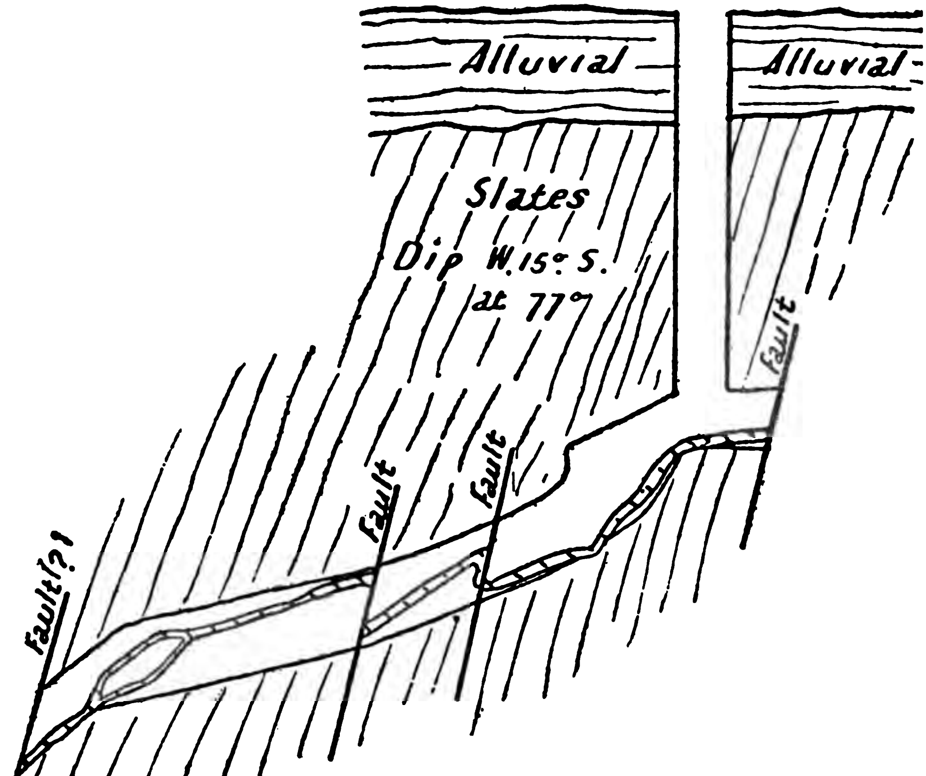


FIG. 3.—Longitudinal Section (Looking North) through Mr. Bond's workings.
Scale, 16 feet to 1 inch.

is a drawing of a small reef which has the same strike as the enclosing slates, but dips across them at a low angle. Three or four small reversed faults are visible in the drive along the reef.

III.—*General Features of Saddle Reefs.*

Before proceeding to the description of the Hargraves saddle reefs it will perhaps be desirable, for the information of those unacquainted with this type of deposit, to give a short account of the general features of these reefs, and at the same time to define the terms in general use.

Saddle Reefs.—This name was applied many years ago to designate certain reefs occurring in the Bendigo Gold-field, which were saddle-shaped or curved over in the form of an arch. These reefs occur in the anticlinal arches of the folds, and lie conformably with the enclosing strata. They comprise, in fact, the material that has filled saddle-shaped cavities produced by the separation of the rocks along their bedding planes during the process of folding.

Inverted Saddle Reefs or Trough Reefs.—These names are interchangeable, and are applied to the trough-shaped reefs which occur in the synclinal troughs of the folds that intervene between the anticlinal arches.

At Bendigo these trough reefs are of much rarer occurrence than the saddle reefs, and are, therefore, of less economic importance; but at Tambaroora, near Hill End, there is every indication that trough reefs will be found to be developed on a very important scale.

Cap and Legs.—The upper arched portion of a saddle reef is known as the cap. This usually constitutes the thickest part of the reef, and in the case of some of the Bendigo reefs is as much as one hundred feet in thickness. The two lateral extensions of the cap are called the legs. These dip in opposite directions and away from one another in the saddle reefs, but towards one another in the trough reefs. When the strike of the reefs is north and south, the legs dip east and west; the former are known as the east legs, and the latter as the west legs.

Centre Country.—This term is applied to the central portions of the anticlines or synclines, where the rocks do not dip very definitely either one way or the other. The terms *east* and *west country* refer respectively to the easterly and westerly dipping strata which occur on the sides of the centre country.

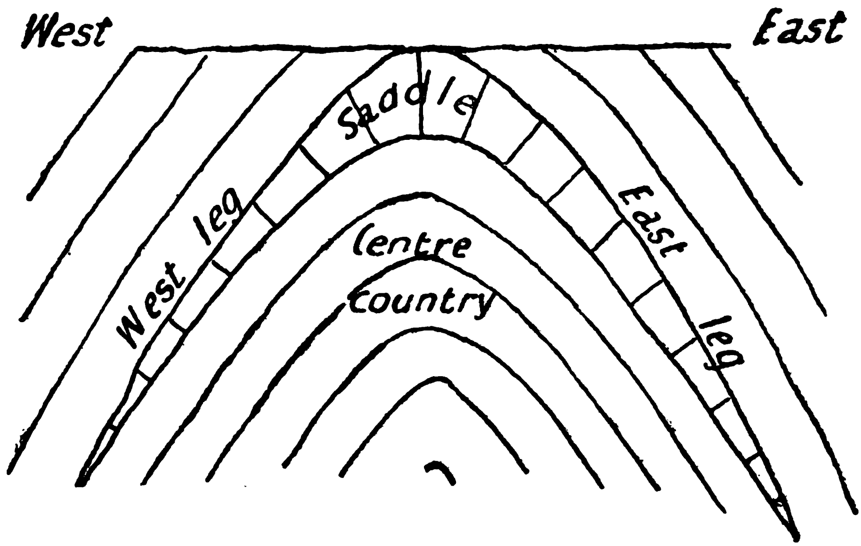


FIG. 4.—Diagrammatic Section of Saddle Reef.

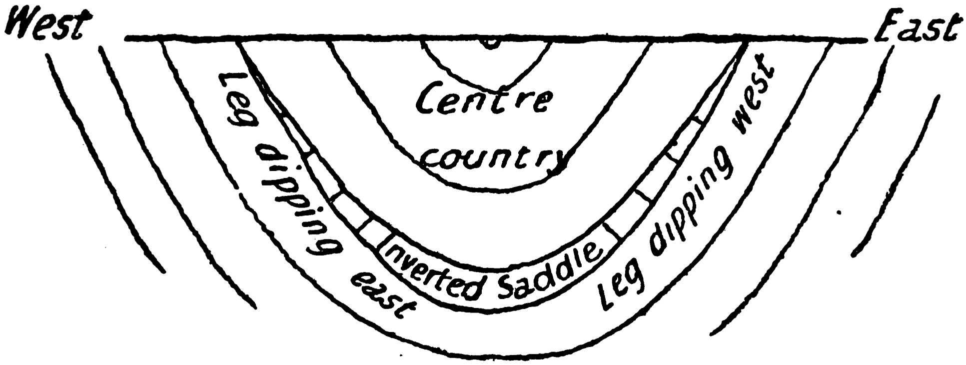


FIG. 5.—Diagrammatic Section of Inverted Saddle (or Trough) Reef.

The accompanying diagrammatic sections of a saddle reef (Fig. 4) and a trough reef (Fig. 5) are given to show the main features of this type of deposit.

Anticlinal Axial Lines, Lines of Reef.—These terms are practically synonymous. They are used to signify the courses of the anticlinal arches and their saddle reefs. No less than eleven of these lines of reef have been traced at Bendigo; and at least four are to be easily made out at Hargraves and two at Tucker's Hill.

Side Lines.—These are lines which mark the positions of the synclinal troughs, along which inverted saddle reefs are occasionally developed.

Dip and Underlay.—These terms are used in their ordinary significance, the former to mean the inclination of a bed from the horizontal plane, and the latter to signify its inclination from a vertical plane.

Pitch.—The folds into which the rocks have been thrown are seldom horizontal for any distance in the direction of their strike. Through longitudinal compression the folds have been thrown into a number of gentle undulations. Where this has taken place in the case of folds striking north and south, they are said to pitch to the north or south as the case may be. The angle of pitch, measured from a horizontal plane, is usually a low one, varying from a degree or two to 20° or sometimes even more.

Centre Country dips East or West.—This is an expression to signify the fact that the folds are usually not perfectly symmetrical with reference to a vertical plane,

but that, generally, as the centre country of a north and south fold is followed down it is found to take up a position either further to the east or to the west, as it dips in one direetion or the other.

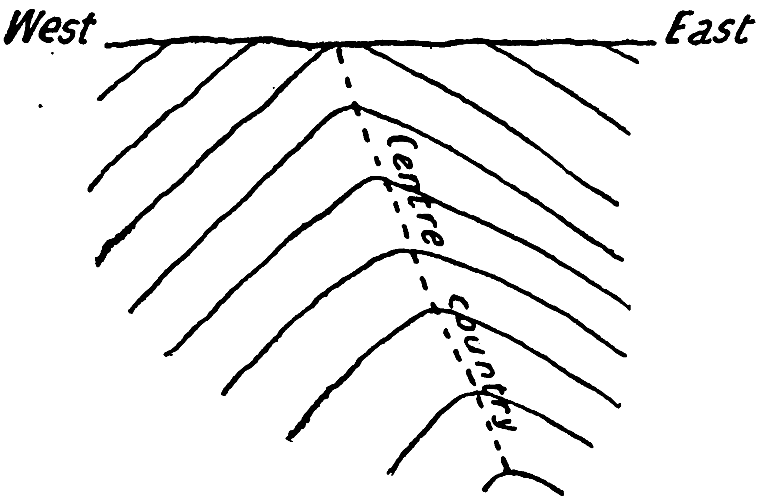


FIG. 6.

In the accompanying sketch, Fig 6, the centre country is shown dipping east. This list is a very important feature, and one that should be borne in mind in conducting prospecting operations. This list of the arches and, consequently, also of the enclosed saddle reefs at Bendigo, varies much, and amounts in places to as much as 1 in 6½, or an inclination of 9° from the vertical plane. In the Great Extended Hustlers Mine, for instance, on the Hustlers line of reef, the centre country is situated eighty feet *west* of the shaft at the two hundred foot level, while at the one thousand eight hundred foot level it is one hundred and sixty feet *east* of the shaft. It has thus moved eastwards two hundred and forty feet in a vertical distance of one thousand six hundred feet.

Outcrops of Saddle Reefs.—Denudation acting on the tilted saddle reefs produce outcrops of a most characteristic form, which are nevertheless very puzzling to miners accustomed to exploit fissure reefs. We usually find that lying across the centre country is a gently arched mass of quartz which on being traced in one direction is found to dip beneath the surface; and in the opposite direction passes into two reefs with opposed dips, which diverge more and more from one another. The mass of quartz which lies across the centre country, and is semicircular or horseshoe shaped in outline, is the cap of a saddle reef, while the two lateral extensions are the more or less denuded east and west legs.

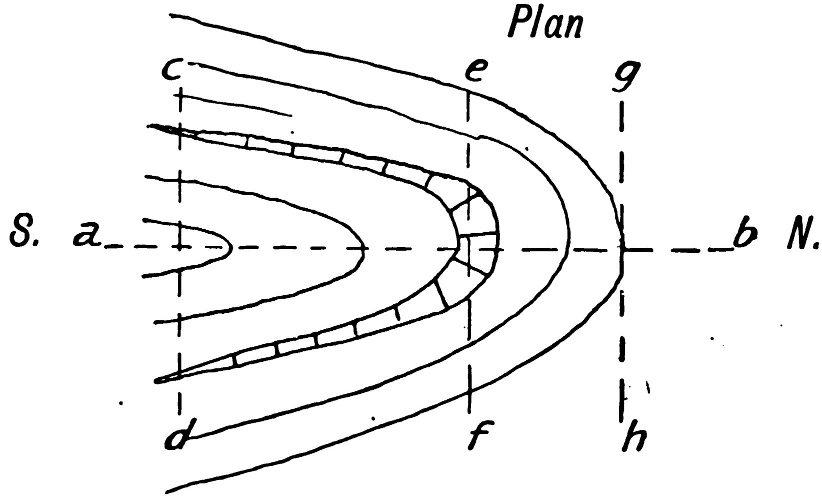


FIG. 7.

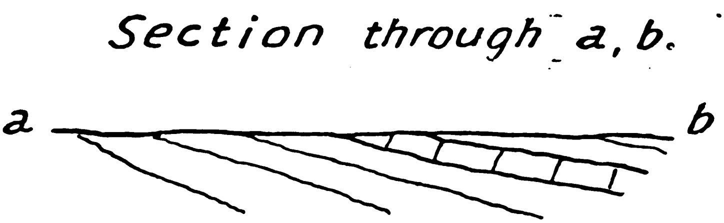


FIG. 8.

Cross sections

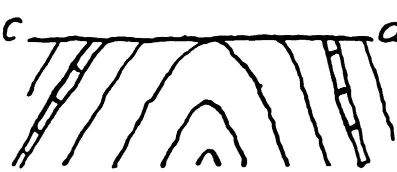


FIG. 9.

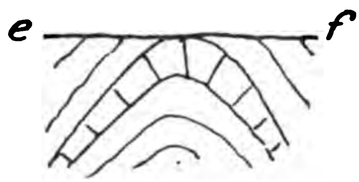


FIG. 10.

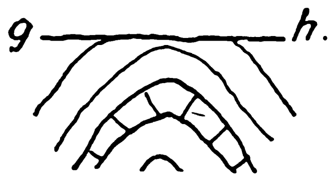


FIG. 11.

The accompanying diagrammatic sketches illustrate this peculiarity of the outcrops of saddle reefs. Fig. 7 is a plan showing the outcrop of the cap and diverging legs of a saddle reef which is pitching to the north. Fig. 8 is a longitudinal section through *a b*, which marks the position of the anticlinal axis; the pitch of the country and the enclosed cap of the saddle reef is shown.

Figs. 9, 10, and 11 are transverse sections along *c d*, *e f*, *g h* respectively, and across the centre country, in which the appearances of the reef in those positions are indicated.

On level ground the leg-reefs or legs would continue to diverge, at the same time decreasing in width so long as the pitch remained in the same direction, the reefs ultimately pinching out. If, however, a change took place in the direction of pitch while the reef still persisted these legs would be found to converge until they again united in a semicircular outcrop, where the cap again makes its appearance.

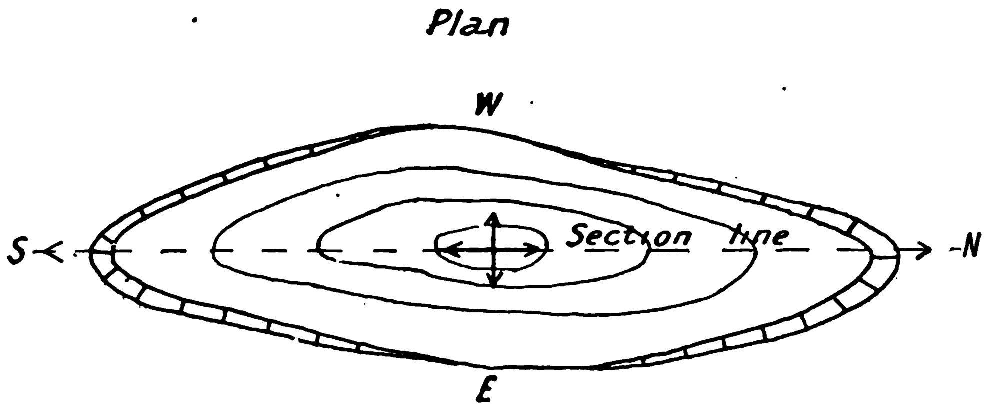


FIG. 12.

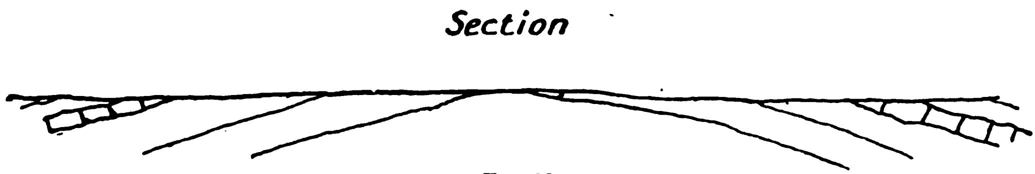


FIG. 13.

This is indicated in the accompanying diagrammetic sketch-plan, Fig. 12, and longitudinal section through the same, Fig. 13.

The outcrops in this case would be those of a reef which originally has the form of an irregular and flattened dome.

At the southern end of the gold-field, and near the Blackfellow's Mine, such a dome-shaped saddle reef was found at twenty feet below the surface.

A drive along the top of this reef showed it to dip at 30° to the north, 25° to the south, 35° to the east, and 45° to the west.

IV.—The Hargraves Saddle Reefs.

There can now be very little doubt but that reefs exist at Hargraves, which resemble in every essential feature the famous saddle reefs of Bendigo, in Victoria, There are outcrops and exposures in the shallow workings at Hargraves which reveal saddle reefs developed in an almost ideal manner. Like the Bendigo reefs they occur in the folds of the rocks, are saddle-shaped, lie conformably with the bedding planes of the strata, and occur in a series one beneath another. Such may be considered to be the essential features of the Bendigo reefs, which are exactly reproduced at Hargraves.

There are, of course, many differences between the reefs that occur at the two places, which are important in themselves from an economic standpoint, and are evident from a mere superficial examination, while others will be discovered when a detailed geological examination of the Hargraves Gold-field has been made; but they are not of an essential character.

One of the most prominent outcrops of quartz at Hargraves is that which originally occupied the surface of Big Nugget Hill, but has now almost disappeared, having been quarried out and crushed. The northern end of the remaining portion of this outcrop is being removed by Lang Bros., and passed through their battery for a reputed yield of several dwt. of gold to the ton.

This large outcrop of quartz is the cap of a saddle reef, which is known locally as the Big Nugget Reef. The cap of it, which has now been almost entirely removed, was in places as much as eight or ten feet thick. One isolated portion—eight feet thick, which on account of its low-grade character is not considered payable, this is shown in the reproduction (Pl. XIV) of a photograph taken from the top of Big Nugget Hill. Tho remains of the cap are seen at (1), while at (2) the quartz has been entirely removed by an open cut, which has exposed the underlying slates. At (3) a portion of the quartz of the west leg can be seen; the east leg is not visible.

On following this cap southwards it is observed to gradually disappear beneath the surface; at one hundred feet south of Spratt and Milton's shaft (Pl. XI) it has been exposed in an open cut six feet below the surface.

These quartz outcrops do not occur irregularly over the Gold-field, but at intervals along well-defined lines, which in the case of saddle reefs correspond with the anticlinal axial lines, and are known as "lines of reef." Five anticlinal arches have been more or less continuously traced on this part of the gold-field, all of which exhibit outcrops of saddle reefs along some part of their course.

A rough survey (Pl. XI) was made of these lines of reef, which run nearly parallel to one another and strike about 20° west of north and east of south.

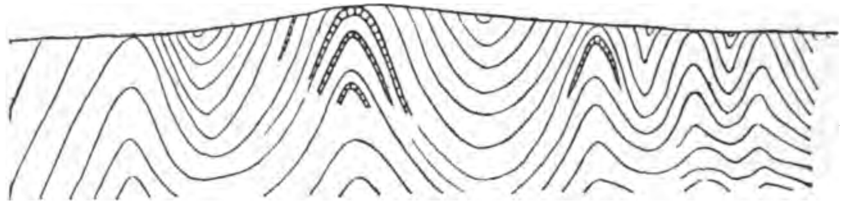


FIG. 14.—Generalized section across the Saddle-Reef-bearing folds at Hargraves.

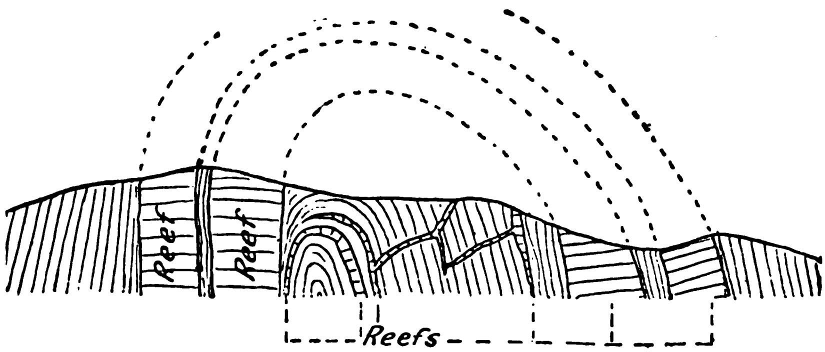
Scale 0 100 200 Feet

Fig. 14 represents a generalised section across them.

The little work done on them proves the existence, near the township of Hargraves, of a belt of country at least one and a half mile in length and a quarter of a mile wide, which contains gold-bearing saddle reefs.

These lines of reef will now be briefly described.

Big Nugget Line of Reef.—The best-defined and most important is that which runs through the centre of Big Nugget Hill, and which can be almost continuously followed from Louisa Ponds Creek, on the north, across Big Nugget Hill to the Blackfellows' Reef, on the south. The most important workings on this line are those on Big Nugget Hill, where several shafts have been sunk to depths varying from a few feet to one hundred and seventy feet. The caps of two large saddle reefs come to the surface on the top of the hill, and have been largely removed and crushed. These saddle reefs pitch to the south and are underlaid by other saddle reefs, also pitching south, which outcrop on the north slope of the hill.



Scale Feet.

FIG. 15.—Transverse section across Big Nugget Hill.

Fig. 15 is a section across Big Nugget Hill at Lang's workings, where four strong reefs, from four to five feet in thickness, and which are the east and west legs of two saddle reefs, are visible. The inner pair of legs are, in all probability, those of the Big Nugget Reef. Within these two much smaller saddle reefs are to be seen, as well as a number of small "spurs," which break across the country. A noticeable feature is the position of the centre of the arch, which lies much nearer the eastern legs than the western.

In Spratt and Milton's Mine the existence of three saddle reefs has been proved between the surface and the bottom, viz., seventy feet. In Fig. 16, which

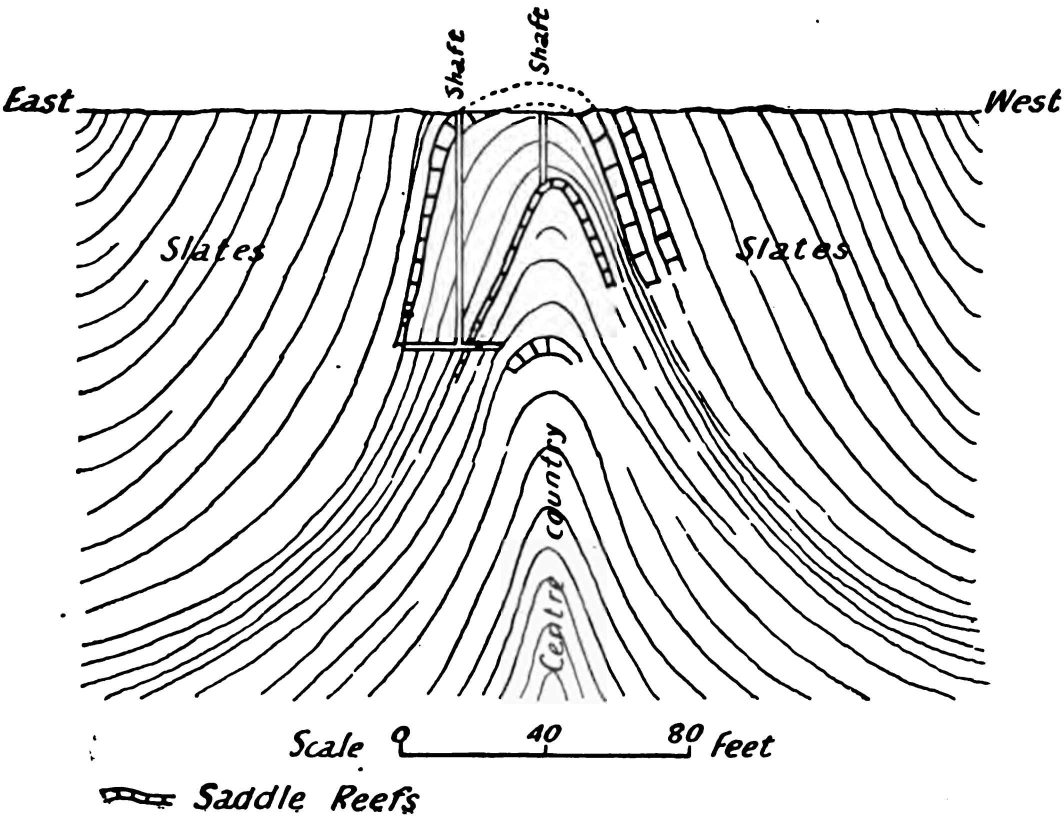


FIG. 16.

is a transverse section, the reefs, as proved by the underground workings, are shown.

That which occurs at the surface is the Big Nugget Reef; twenty feet below this is a second, while a third occurs at forty feet below the second. No attempt

has been made to carry on prospecting operations in the centre country below this level, so that it is not known whether other reefs exist below this. It is highly probable that there are more.

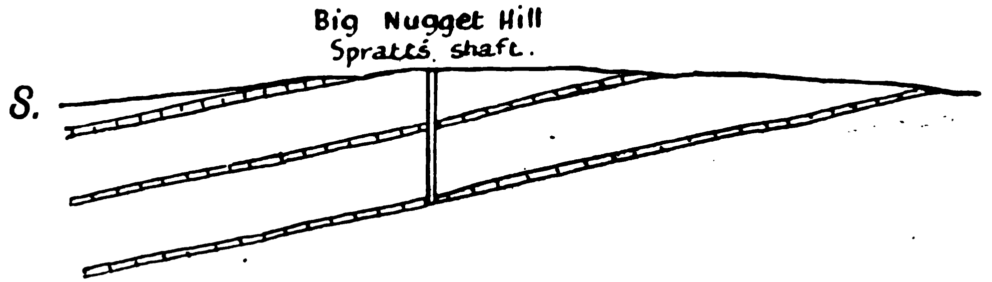


FIG. 17.—Longitudinal Section through Big Nugget Hill.
Scale—100 feet to 1 inch.

Fig. 17 represents a longitudinal section through the centre of Big Nugget Hill, which shows the southerly pitch of the caps of the saddle reefs.

Proceeding to the north along this line of reef the caps of several other reefs are to be seen, the strong southerly pitch of the saddle country bringing them to the surface. About seven hundred feet north of Big Nugget Hill is the Faith Rewarded Mine, in the vicinity of which the caps of two reefs appear at the surface. After crossing the Louisa Ponds Creek this line of reef disappears beneath alluvial deposits, about twenty feet in depth, which have been worked and reworked for gold, yielding large quantities of the precious metal.

It is again picked up at the Lizzie Watson Mine, where several saddle reefs have been worked.

A change in the direction of pitch is now seen to have taken place, for in the lastmentioned mine the saddle reefs pitch to the north, the caps getting deeper the further north they are traced.

Thus, between Big Nugget Hill and the Lizzie Watson Mine there is a longitudinal anticline. The line of reef continues on from the Lizzie Watson Mine, at least as far as the point where it crosses the Creek and near an old church.

South of Big Nugget Hill the centre country of this arch can be followed for about three hundred yards, after which it disappears beneath recent alluvial deposits, which in many places were highly auriferous. Further south still its course is marked by occasional outcrops of quartz in the form of flat-lying masses which appear to be the caps of saddle reefs.

At Gillen's Workings there is a cap of a saddle reef, worked by an open cut, which is not in the form of a simple arch, but contains a number of subsidiary folds (Fig. 18).

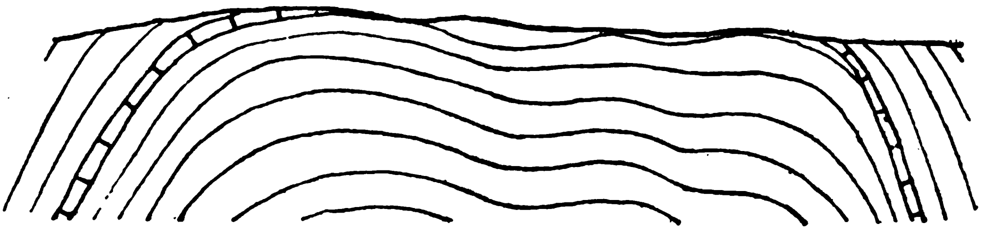


FIG. 18.—Transverse section across Big Nugget Line of Reef at Gillen's Workings.
Scale—40 feet to 1 inch.

At the Alma Mine an easterly dipping reef has been somewhat extensively worked, and has yielded some very rich patches of stone. About one hundred feet west of the Alma Reef a westerly-dipping reef exists, which has been little worked. These two reefs are the legs of a saddle reef, and are joined at their northern extremities by the cap of the reef. This saddle reef pitches to the north. A change in the direction of pitch has taken place between this place and Big Nugget Hill, which indicates the existence of a longitudinal synclinal trough, whose centre seems to be situated in the vicinity of Gillen's Workings.

The same line of reef can be traced still further north, for on a low hill just to the north of the Blackfellow's Mine a large quartz cap of a reef occurs, and twenty feet below the surface the cap of another saddle reef has been found; the latter distinctly dome-shaped.

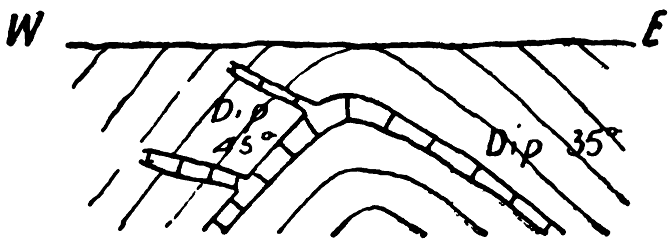


FIG. 19.

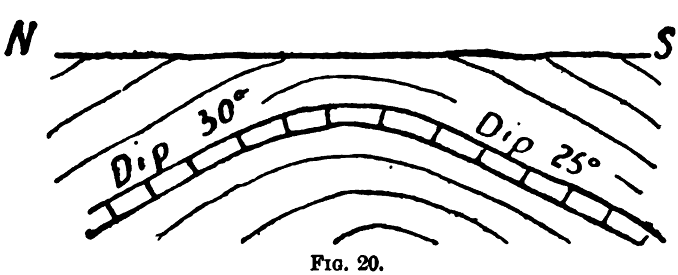


FIG. 20.

Fig. 19 is an east and west section across this latter reef, and Fig. 20 a north and south section across it. The angles of the dip vary from 25° to 45°. A little further south is the Blackfellow's Mine, in which a reef was worked that yielded some very rich stone. This is the most southerly point to which the Big Nugget line of reef has been traced.

Florence Line of Reef.—About two hundred and fifty feet to the east of the Big Nugget line of reef, and running parallel with it, is a second anticlinal arch, which is known to carry saddle reefs. As the Florence Mine, which comprises the most important workings on this line, is abandoned, it was not possible to examine the underground phenomena. During my former visit I thought the Florence Reef was part of the Big Nugget line. I have found since, however, that a synclinal trough exists between the Florence Mine and Big Nugget Hill, proving conclusively that the Florence Reef is on a distinct line.

The Florence line of reef has not been traced for any distance, as alluvial deposits occupy there a large part of the surface; but Loneragan's Workings (Pl. XI), and a saddle-reef situated about three hundred feet east of the Alma Reef, are very probably on this line.

The cap of the Florence Reef is said to have been six feet thick and ten feet wide. Of the legs, the eastern one was the strongest, being from eighteen inches to two feet thick at a depth of one hundred feet below the cap. The stone from this east leg averaged nearly half an ounce of gold per ton. The west leg was much smaller, but the stone from it yielded over an ounce per ton. The mine is now idle, having been abandoned owing to the expense of working arising from the presence of a large body of water in the mine.

The Frenchman's Line of Reef.—About one hundred feet east of the Florence line of reef is a third articlinal arch, along which the outcrops of several caps of saddle reefs are to be seen. The work on this line has been practically confined to the Frenchman's Mine, which is situated about a quarter of a mile to the south-east of Big Nugget Hill. Like many others on this gold-field this mine has been abandoned. The bending over of the centre country can be distinctly seen on

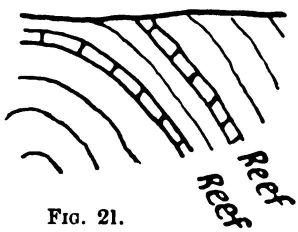


FIG. 21.

the surface, as indicated in Fig. 21, which is a sketch of an exposure in a shallow open cut Two westerly-dipping reefs, each a foot in thickness, and fifteen feet apart, are visible. These are west legs; the east legs are not exposed. The removal of the soil from a patch of ground about two hundred feet north of this mine has revealed the sharp curving of the strata across the centre country, indicating very acute folding.

Sixty feet east of the Frenchman's line of reef is a fourth anticlinal arch, very narrow and very acute, in which a small saddle reef could be seen.

Other folds exist to the east of this, but as they were not examined it is not known whether they contain saddle reefs or not.

Two hundred feet west of the Big Nugget line of reef is another reef-bearing arch (the fifth), which, however, has not been traced far in either direction. On the north it reveals itself in several places, where the surface soil has been removed, by the presence of outcrops of strata, which are bent round and across the centre country. This results from the pitching of the folds, which brings the curved cap of one stratum after another to the surface. The direction in which these outcrops are curved—*i.e.*, whether their convexities are turned northwards or southwards—is regulated by the direction of pitch of the folds.

On a horizontal surface, for instance, the outcrop of any well-marked stratum in a fold which is pitching in any direction is found to form a curve whose convex surface is always turned in the direction of the pitch in the anticlinal arches, but in the opposite direction in the synclinal troughs.

This feature is beautifully illustrated at Tambaroora, eighteen miles south of Hargraves, where, as also at Hill End, there are indications that saddle reefs exist. At Tambaroora (Fig. 22), an outcrop of quartz can be traced round in the form of a double curve, thus ∾.

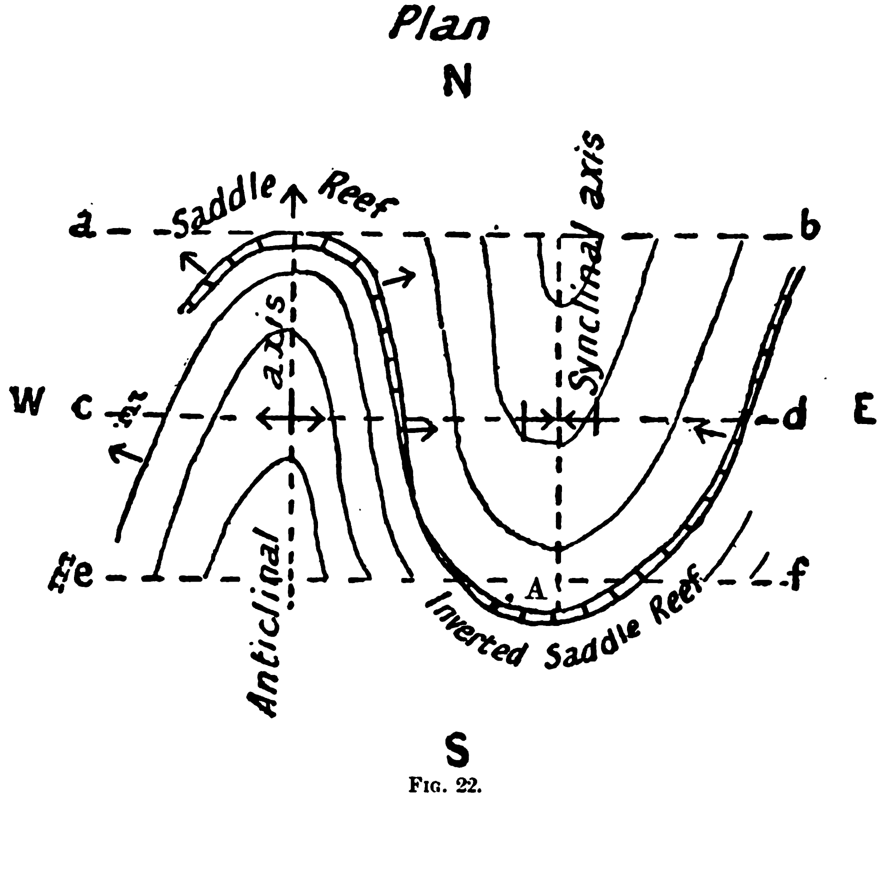


FIG. 22.

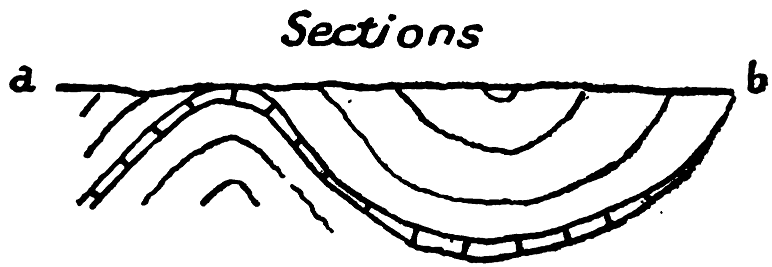


FIG. 23.

FIG. 24.

FIG. 25.

Mining operations carried on at A have proved the existence of an inverted saddle or trough reef, which pitches to the north at an angle of about 20°.

The horseshoe-shaped outcrop of this reef has its convexity turned to the south—that is, in the opposite direction to the pitch of the fold, which is there to the north. This outcrop of quartz can be traced round to the west, and is found to be continuous with a saddle reef, the convexity of whose outcrop is directed northwards—that is, in the direction of the pitch.

The continuity of the quartz from an arch to a trough, forming conjoined saddle and inverted saddle reefs, must be looked upon as a very rare and almost unique occurrence.

Figs. 23, 24, and 25 are vertical sections along the lines *a b*, *c d*, and *e f* respectively.

Traced south of Big Nugget Hill, this fifth arch is found to pass through some old workings, where portions of saddle reefs have from time to time been worked. It then, in all probability, passes through Happy Dick's Hill, where two westerly-dipping reefs—probably west legs—have been worked.

West of this line of reef, the slates appear to dip uniformly to the west, at least as far as the Public School, where the so-called " dyke " makes its appearance.

Side Lines.—Between the several lines of reef are synclinal troughs, which, when reef-bearing, are known as side lines. Along these side lines occur the inverted saddle reefs, which are of rather rare occurrence. At Hargraves the only outcrop of such a reef that came under my notice was one that occurs about three hundred feet to the east of the Alma Reef. This reef (Pl. XI) is six inches in thickness at its outcrop, and has been worked on a small scale, yielding stone which varied from six to sixteen pennyweights of gold per ton.

At Tambaroora reefs of this character seem to assume important proportions.

V.—The Tucker's Hill Saddle Reefs.

Two miles north-east of Hargraves is Tucker's Hill, down the side of which the Mudgee Road runs. It is in the form of a narrow elongated ridge with steep sides, and strikes about north-north-west and south-south-east.

A somewhat peculiar feature is the fact, that for a portion of its length the crown of the hill coincides with the cap of an anticlinal arch. This is particularly noticeable at the northern extremity of the hill, where the quartz cap of a saddle reef curves over the crown of the hill. On its eastern slope (*see* Fig. 26) two

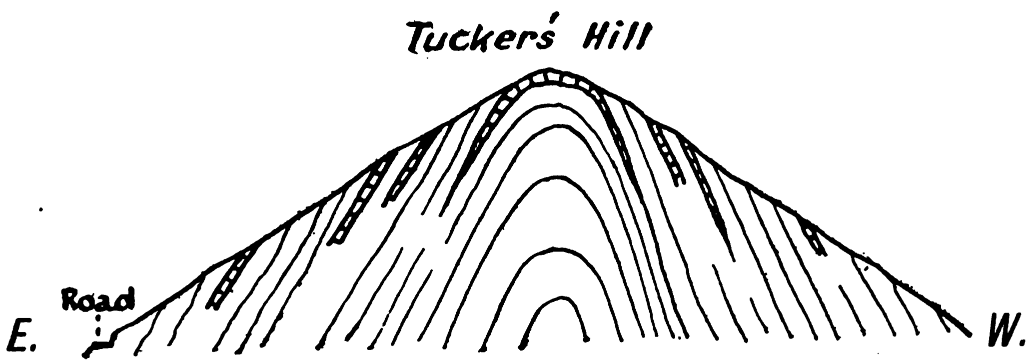


FIG. 26.—Section across Tucker's Hill.
Scale—100 feet to 1 inch.

easterly dipping reefs were worked many years ago; the first is distant about fifty feet from the crown of the hill, and the second about twenty feet lower down. About seventy feet below the latter, a third easterly-dipping reef crops out on the surface. These are very probably east legs of saddle reefs, whose upper portions

have been denuded, for in very nearly corresponding positions on the opposite slope of the hill are three westerly-dipping reefs, or, as they most probably are, west legs.

No work has been done in the neighbourhood of the centre country to prospect for underlying saddle reefs.

A second line of saddle reefs exists to the east of the one just mentioned, from which it is separated by a synclinal trough carrying several small inverted saddle reefs.

This locality deserves much more attention at the hands of prospectors than it has yet received.

VI.—Reefs other than Saddle Reefs.

Several reefs have been worked at Hargraves which do not belong to the saddle system. The most important is that known as the Eureka, which, for its size, has been the richest reef on the field. The workings on this reef are situated about six hundred yards north-west of Big Nugget Hill. It strikes north 10° east, and dips at a low angle to the south; thus, unlike the saddle reefs, it cuts across the bedding planes of the slates, which strike about north 20° west.

A rich shoot in this reef was followed down and contained, besides a large quantity of free gold, some very rich bunches of arsenical pyrites.

After the reef had been worked by Mr. Bond and others, the property was acquired by a company who sunk a shaft, about three hundred feet south-east of its outcrop, to a depth of two hundred and forty feet, but failed to cut the reef. From the bottom of this shaft, two long cross-cuts were driven, one to the east and the other to the west, without, however, cutting any payable reefs.

The western cross-cut was extended as far as the "dyke" (Pl. XI), which, where intersected, was about twenty feet wide.

The rock constituting this "dyke" was thought to be gold-bearing; and in order to test this five tons were sent to Melbourne for treatment, but no gold was extracted from it.

The eastern cross-cut intersected several reefs, but none of them were found to be payably auriferous. It will be readily understood that the only rational way to prospect for ore-bodies of the saddle-reef type is not by driving long cross-cuts but by penetrating the centre country, or the arches, where, if saddle reefs exist, their presence cannot fail to be detected.

Another reef from which very rich quartz was obtained is that formerly worked by Mitchell, which is situated about two hundred and fifty yards south of Big Nugget Hill, and a little to the east of that line of reef. This reef strikes east and west, and dips to the south at an angle of about 30°. The low angle of dip is a noticeable feature of these reefs that cut across the bedding planes. Another peculiarity is their corrugated structure, the reef being thrown into innumerable small folds. A very remarkable feature about these reefs is the distribution of their gold contents, which appears to have been regulated by the presence of what are locally known as "marks." These appear to be thin bands of dark brownish green slate, which carries sometimes a thin seam of quartz from one-eighth to half an inch in thickness.

The occasional presence of a stiff clay seam, known as "flucan" or "dig," shows that they are sometimes planes of movement.

Along the intersection of the mark and the reef there is usually a rich deposit of gold, which does not appear to extend laterally into the surrounding portions of the reef, which is thus barren on either side of the mark. Experience has proved this to be such a well-marked and constant feature, that where reefs of this character are being worked, prospecting operations are practically confined to a narrow strip following the intersection of the mark and reef.

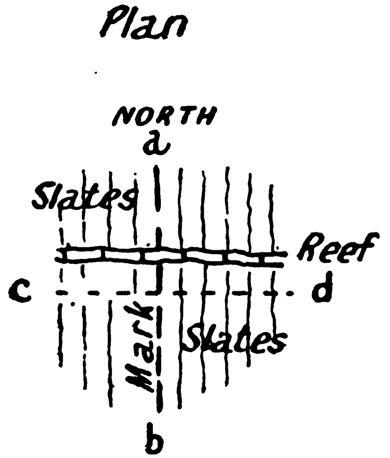


FIG. 27.

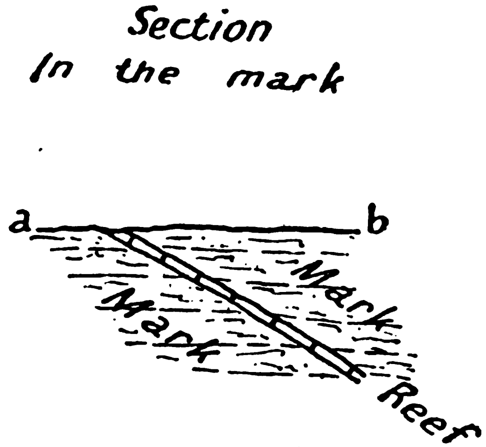


FIG. 28.

The accompanying sketches illustrate the relation of the mark to the reef, and of these to the country rock, as seen in Mitchell's Workings.

Fig. 27 is a plan showing the mark whose strike and dip are the same as those of the enclosing slates, and the reef. Fig. 28 is a section in the mark, which shows

the valuable part of the reef. Fig. 29 is a transverse section along c d, which shows the corrugated form of the reef and the conformability of the mark with the country rock.

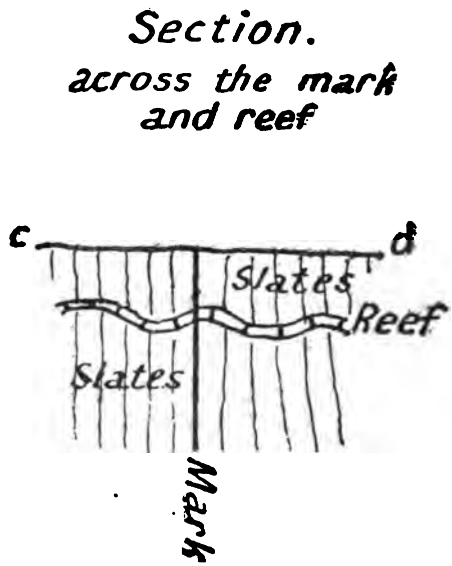


FIG. 29.

The rationale of the influence of the marks upon the distribution of the gold in these reefs is not understood. All that can be safely affirmed is that in the vicinity of the marks the conditions were much more favourable for the deposition of gold from the circulating mineralised solutions than elsewhere. What naturally suggests itself is that the rock composing the mark contains an active precipitating agent which caused the deposition of the gold in its vicinity to the detriment of the surrounding portions of the reef, which, without exception, are poor in gold.

VII.—Summary.

The evidence that I have been able to bring forward is, I trust, sufficient to establish the fact that the remarkable type of ore-deposit, known as saddle reef, which is so characteristic of the Bendigo Gold-field, occurs also at Hargraves in this Colony.

The scientific interest attaching to the study of these reefs is unquestionable, but what is of more importance at this juncture is to determine their economic value. To do this it will be necessary to carry on extensive prospecting operations. But that money may not be uselessly spent, it is of the utmost importance that a knowledge of the peculiar features of saddle reefs, as well as of the particular structure of the saddle-reef country at Hargraves, should guide those who undertake this work.

It would be difficult to find an instance in which geological knowledge could be of more assistance to the mining industry than in the present case.

It has now been shown that at Hargraves saddle reefs occur along at least five parallel lines, and appear at intervals at the surface over a distance of about two miles. There is also evidence of the existence of a second system at Tucker's Hill, two miles north-east of Hargraves, where at least two lines of such reefs are developed. Lastly, twenty miles south of Hargraves, at Hill End and Tambaroora, there are indications that similar reefs occur. It is thus very probable that reefs of this character occur over a somewhat large area in this part of the Colony.

X.—On the Occurrences of a Cyclopterid Fern, closely allied to the European *Cardiopteris polymorpha*, Goeppert, in the Carboniferous of New South Wales: by W. S. DUN, Assistant Palæontologist.

[Plate XV.]

THE Carboniferous genus *Cardiopteris*, in which several of the species originally referred to Brongniart's *Cyclopteris* are now included, has not up to the present been described from Australia. The general subjects of the nature of cyclopterid leaves, their terminology and the genera to which they are referred, will be dealt with later on.

The specimens described in this note were collected from the *Rhacopteris* beds of Paterson by Messrs. J. E. Dobson and C. A. Sussmilch. The specimens at my disposal consist mainly of detached pinnules, so that in those cases general appearance is all that can be gone by. The pinnules in our specimens are of the usual circular-ovate type, and some which are assumed to have been situated near the apex are more elongate. The usual dimensions are from 25–30 mm. long and about 20–25 mm. broad. A more elongate one is 42 mm. long and 24 mm. broad. As remarked before, with one indistinct exception, the pinnules are detached. In that case (Pl. XV, fig. 5) they appear to be opposite, but owing to the mass of leaf impressions crowded round it is impossible to make out the phyllotaxy along any extent of the rachis. The venation is fine, frequently forking. The margin is entire.

After comparison with the figures of European and American species, I have come to the conclusion that the Paterson leaves are very closely allied to *C. polymorpha*, Goeppert,* originally described as *Cyclopteris*. This species has been

* Flora Sil. Dev. u. Unt. Kohlenform.—Verhandl. K. Leop. Carol. deutsch. Akad. Naturforscher, 1869, XXVI, p. 502, t. 8, f. 5.

referred by Stur * to Ettingshausen's *C. Hochstetteri* †; but Mr. R. Kidston remarks ‡ that the character on which Stur placed most reliance for retaining them as separate species is the fact that whilst the pinnules in *polymorpha* are opposite, in *Hochstetteri* they are alternate. As he points out, Stur's figures of *Hochstetteri* in the "Culm Flora," Part I, show both alternate and opposite pinnules, and remarking "the alternate or opposite arrangement of pinnæ or pinnules appears to be a character of little value, as they are frequently alternate and opposite on different parts of the same frond," he places *C. Hochstetteri* as a synonym of *C. polymorpha*. The specimens at my disposal consist mainly of detached pinnules, so that in these cases general appearance is all that can be gone by. I have, unfortunately, not been able to refer to the original description by Goeppert of his *polymorpha*, and have had to depend on the figures and description of plants referred to that species by Renault,§ Schimper,‖ Zeiller,¶ and Feistmantel,** together with those of *Hochstetteri*, by Stur and Ettingshausen, already referred to. A glance at the figures (Pl. XV, fig. 3–5) will show that it has little in common with *C. frondosa*, Goeppert, and *Haidingeri*, Ettingshausen, the lesser size and much restricted area of attachment of the pinnules at once separating them from both those species—which have been classed together by Mr. Kidston. To Stur's figures of his *Hochstetteri*, however, there is the greatest resemblance. The pinnules of the upper portion of the frond, however, in that species are oblong-ovate, but having a relatively greater point of attachment, and those of the lower portion being more petiolate. The dimensions are about the same, and the venation, judging from the figures, is identical. The same may be said generally for the forms figured in the other works quoted.

From beds of the same age at Mount Hungry, Paterson, Mr. C. Cullen collected some pinnules, detached, and of a much greater size, and apparently more of the nature of *C. frondosa*, Goeppert, than those just described. The largest pinnule is 57 mm. long and 43 broad. The actual base is not known, but it appears to be not so petiolate as in the case of those species of the *polymorpha* type and nearly approach *C. frondosa*, Goeppert, as figured by Schimper.†† One specimen (Pl. XV, fig. 1) shows two adjunct pinnules, imperfect and with the rachis removed. The margin is entire, venation fine and frequently branching.

It appears probable that these represent large pinnules of the previously described forms referred to *Cardiopteris*. The size in leaves of this type is variable even on the same frond, as may be seen in the specimens figured by Schimper, Zeiller, and Lesquereux amongst others.

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* Die Culm Flora, Heft. 1.—Abhandl. K. K. Geol. Reichsanstalt, 1875, VIII, p. 48, t. 14, f. 2, 3.
† Foss. Flor. Mährish.-Schlesischen Dachschiefers. Denks. K. Akad. Wissen. 1865, XXV, p. 97, t. 6, f. 3.
‡ B. M. Cat. Pal. Plants, 1836, p. 84.
§ Cours. Bot. Foss., 1883, III, p. 202, t. 35, f. 2, 3.
‖ Traité Pal. Veg., 1869, I, p. 452.
¶ Vég. Foss. Terr. Houiller, 1879, p. 47; Veg. Foss. Terr. Trans. Vosges, 1862, p. 339, t. 25, f. 1-7
** Zeits. deutsch. Geol. Gesell., XXV, p. 522, t. 16, f. 21-24.
†† *Op. cit.*, t. 35, f 2.

II.—Relations of Cyclopterid Pinnules.

One of the most recent articles on *Cyclopteris* is that by Mr. A. C. Seward,* to which I am indebted for much of the following matter relating to the various interpretations of the generic term and the relations of the pinnules that have been from time to time classed under it. First described by Brongniart† as possessing a "Fronde simple, entiére, le plus souvent orbiculaire ou réniforme; nervures nombreuses toutes égales, dichotomes, rayonnant de la base," he some years later divided the species he originally described into *Cyclopteris* and *Nephropteris*.‡ His now somewhat restricted *Cyclopteris* have "Fronde simple, pédicellée, symétrique, arrondie, cordiforme, ou flabellée, entiére; ou lobée, sans apparence de nervure médianne, toutes les nervures partant de la base du limbe, et se divisant en se dichotomant pour atteindre la circonférence"—single, stalked pinnules; while *Nephropteris* comprises "Frondes isolées, simples, sessiles, obliques, non symétriques arrondis ou cordiformes, ordinairement concaves et ombiliques à leur base." Brongniart considered that these sessile leaves, otherwise like those of *Cyclopteris*, were probably the basal pinnules of *Neuropteris* and *Odontopteris*. Lindley and Hutton§ consider that *Cyclopteris obliqua*, referred by Brongniart himself to *Nephropteris*, is rather referable to *Neuropteris* than *Cyclopteris*. Mr. Seward states that Lesquereux,‖ at first, retained *Cyclopteris* "and considers that all Cyclopteróid leaves attached to stems form a distinct genus; those without stems and with arched nervures are included in *Neuropteris*, those without stems and straight and diverging nervures are classed with *Odontopteris*. The Cyclopteroid leaves with stems are retained in the genus *Cyclopteris*, which is subdivided into three sections:—(*a*) Adianthoides; (*b*) Odontopteroides; (*c*) Neuropteroides." Later, however, he no longer considered *Cyclopteris* to be a valid genus, evidence connecting with *Neuropteris* having been obtained,—the pinnules of the latter being without midrib.¶ This was confirmed by Roehl,** who describes *Neuropteris Loshii* with cyclopteroid pinnules. Schimper,†† in 1869, founded the genus *Cardiopteris* on the type of *Cyclopteris polymorpha*, Goeppert, a large pinnate fern with almost equilateral pinnæ, pinnæ opposite, auriculate at base, contiguous, margin reflected, nervation frequently dichotomous, radiate and diverging. He refers to this—*Cyclopteris frondosa*, *Hochstetteri*, *frondosa*, *Koechlini*, and *Haidingeri*, Mr. Seward remarks that the pinnules of *Cardiopteris frondosa* resemble *Neuropteris* rather than *Cyclopteris*. Schimper elsewhere states that he excludes

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* Geol. Mag., 1888, V (3), pp. 344–347, t. 10.

† Prodr. Hist. Végét. Foss., 1828, p. 51; Hist. Végét. Foss., 1828–37, tt. 61, 61 bis (*fide* Seward).

‡ Tableau des genres de Végét. foss., considérés sous le point de vue de leur classification botanique et leur distribution géologique, 1849, p. 16.

§ Fossil Flora, 1833–35, II, pl, 90.

‖ H. D. Rogers, Geol. Pennsylvania, Descr. Foss. Plants, 1858, II.

¶ Rept. Geol. Survey Illinois, 1866, II, p. 427.

** Palæontographica, 1869, XVIII, t. 17.

†† Traité Pal. Vég., 1869, I, pp. 451–453, t. 35.

from *Cyclopteris* all species with pinnate fronds, of which most belong to *Neuropteris*. According to him, *Cyclopteris* is the transition between Sphenopterideæ and Neuropterideæ—(*op cit.*, p. 420). He accepts as good species *Cyclopteris trichomanoides*, Brongt., *lacerata*, Heer, *flabellata*, Brongt., *Liebana*, Geinitz, and *crenata*, Brauns. *Nephropteris* (*op cit.*, p. 429.) is only to be considered as provisional. Lesquereux,* in a later work, considers that *Cyclopteris* and *Nephropteris* should be abandoned, referring most to *Neuropteris*. Feistmantel† also contributed a paper on the subject in 1873, stating that though some *Cyclopteris* might be basal pinnules of *Neuropteris*, yet others agreed in all points with the original diagnosis. Grand Eury‡ refers *Cyclopteris* to *Neuropteris* and *Odontopteris*. Mr. R. Kidston§ abandons *Cyclopteris* entirely, referring most of the species to *Neuropteris* and *Palæopteris*, and two—*frondosa* and *polymorpha*—to *Cardiopteris*. Mr. A. C. Seward,‖ in the concluding paragraph of the paper to which I have to so great extent been indebted for these facts, says: "In the present state of our knowledge it would be premature to speak positively as to the claims of *Cyclopteris* to be considered a distinct form; the specimen before us seems to justify our retaining for the present Brongniart's original genus." Stur¶ also refers some species to *Cardiopteris*. Renault** speaks of *Cyclopteris* as being "flabelliform leaves, orbicular, reniform, margins entire or notched, sessile or sub-sessile, frequently associated with fronds of *Odontopteris* and *Neuropteris*, and sometimes also attached to the rachis of these fronds; these are then stipal leaves, which can, to a certain extent, be referred to the ferns which bore them." Solms-Laubach, in his "Fossil Botany,"†† draws attention to the great similarity between various *Cyclopteris* (*obliqua*, *reniformis*, *dilatata*, *rarinervis*), and the leaves figured by Saporta as belonging to *Dolerophyllum*, most probably one of the Cordaiteæ; but this resemblance may be only superficial, and has yet to be confirmed by microscopic structure. In speaking to the "Nervatio Cyclopteridis" he says:‡‡ "That it is with difficulty, in some cases, distinguished from *Neuropteris*, and that most of the Coal-Measure ferns with the cyclopterid venation belong to *Odontopteris*."§§ Potonié, in his "Lehrbuch der Pflanzenpalæontologie" follows the same course as Kidston, referring *Cyclopteris polymorpha* and *frondosa* to *Cardiopteris*.

From the above-mentioned definitions it appears that the term *Cyclopteris* has been very loosely used, and, strictly speaking, can only be applied to isolated pinnules. These isolated pinnules with the "*Nervatio Cyclopteridis*" are commonly associated

* 2nd Geol. Survey, Penn.: Descr. Coal Flora Carb. Form., 1880, I, p. 74.
† Zeits. deuts. Geol. Gesell., 1873, xxv., pp. 521–524.
‡ Flor. Carb. Dept. Loire, 1877, p. 379.
§ B.M. Cat. Pal. Plants, 1886, p. 90.
‖ Geol. Mag., 1888, V (3), pp. 344–347.
¶ Culm. Flora, Heft 1, 1879, p. 43 (Abhand. K.K. Geol. Reichsanstalt, VIII.)
** Cours Bot. Foss., 1883, III, p. 184.
†† English Trans., 1891, p. 125. (8vo., Oxford.)
‡‡ *Op. cit.*, p. 136.
§§ *Op. cit.*, p. 137.

with *Neuropteris* and *Odontopteris* in Upper Palæozoic rocks. Sphenopterids are also abundant; so it is but natural to assume that these leaves are but portions of larger fronds, and this is proved by the fact that the basal pinnules of both *Neuropteris* and *Odontopteris* are quite indistinguishable from them. The term *Cardiopteris* has also been applied to fronds bearing these pinnules entirely. The association in New South Wales is with great abundance of *Rhacopteris inæquilatera* and *septentrionalis*, and also *Archæopteris Wilkinsoni*, all ferns with the Cyclopterid venation; but though I have seen many hundreds of *R. inæquilatera* from these beds, no pinnules at all like the subjects of the present note have been found attached to them.

XI.—On the Occurrence of Phosphatic Deposits in the Jenolan Caves, New South Wales: by JOHN C. H. MINGAYE, F.C.S. Analyst.*

THE existence of phosphatic deposits in the numerous caves at Jenolan have not, as far as I am aware, been previously recorded.

To Guide Wyburd credit is due for first bringing these deposits, which have since been found to be of phosphatic origin, under the notice of the Department. The phosphates occur in Katie's Bower, Left and Right Imperial, Grotto Cave, and the Jubilee Cave—a branch of the Right Imperial Cave.

Mr. Harper, Assistant Curator, Geological Survey Branch, having recently visited the Caves, has very kindly favoured me with his observations and various notes in connection with their occurrence.

Geology.—Professor David, B.A., F.G.S., states, with regard to the geology of the Caves district:—"The Caves, which are large and very numerous, occur in a thick bed of limestone. The limestone is formed largely by corals, hydro-corallines (*Stromatoporella* being very abundant), and brachiopods; amongst the latter a large *Pentamerus* predominates. The limestone is considered by R. Etheridge, junr., to be of Siluro-Devonian age. It is interstratified with a thick series of blackish, greenish, grey, and reddish-brown clay shales, claystone, and cherts, these containing casts of radiolaria. The whole of the sedimentary series are intruded by quartz-felsites, and basic dykes, rich in augite." Mr. Harper, who recently visited the Caves, informs me that a quantity of drift is associated with or immediately overlies the red and white marls which partly fill portions of the caves. The marls appear to graduate downwards, and are red and white in colour."

* Published in abstract in Trans. Austr. Assoc. Adv. Sci., Sydney Meeting, 1898 [1899], VII, pp.

A sample of the reddish marl taken from the Devil's Coach-house yielded on analysis as follows:—

Analysis.

Hygroscopic moisture	1·49
Combined water	3·01
Silica (SiO_2)	63·41
Alumina (Al_2O_3)	18·02
Ferric oxide (Fe_2O_3)	7·33
Manganous oxide (MnO)	trace.
Lime (CaO)	·16
Magnesia (MgO)	·79
Potash (K_2O)	5·09
Soda (Na_2O)	trace.
Phosphoric acid (P_2O_5)	·08
Organic matter	·24
	99·62

(1 and 2.) Light, porous, friable substance, white in colour; soluble in dilute muriatic acid. Found in Katie's Bower, Left Imperial Cave.

This deposit occurs in veins in the marls. The presence of a large quantity of red clay is very noticeable in this cave; in fact, it forms the boundary at one end of the earth deposit. The clay is also present in the "wash," being possibly the fine sediment deposited in the side channels and quiet pools of a one-time underground river.

There is no evidence of bat guano or bone breccia in any part of this cave.

Analysis.	I	II
Moisture and combined water	33·60	9·83
Silica (SiO_2)	·70	50·10
Alumina (Al_2O_3	26·83	13·88
Ferric oxide (Fe_2O_3)	·72	8·65
Lime (CaO)	8·10	1·02
Magnesia (MgO)	·14	·14
Potash (K_2O)	·09	1·35
Soda (Na_2O)	absent	trace.
Phosphoric acid (P_2O_5)	30·04	15·38
Carbonic acid (CO_2)	·15	·12
Chlorine (Cl)	minute trace	......
	100·37	100·47

No fluorine or sulphur trioxide present.

(3.) The deposit was found on the floor of the Grotto Cave, and is protected with a hard surface, covered with small gnarled excrescences, found to be gypsum. Mr. Harper, who examined this deposit, informs me "that it would appear as if it resulted from the alteration of the limestone from below, and is not connected in any way with the drift or marls."

There are similar deposits of this material in the Bone Cave, Lucas Cave, and in the Wool-shed Imperial. No indications of bat guano or bone breccia were observed.

Two samples of this material, very similar in appearance, yielded on analysis as follows:—

Analysis.	I	II
Moisture and combined water	16·82	22·59
Silica (SiO_2)	37·82	2·78
Lime (CaO)	22·66	31·52
Magnesia (MgO)	·32	·09
Alumina (Al_2O_3)	·64	·10
Ferric oxide(Fe_2O_3)	minute trace	absent.
Potash (K_2O)	·11	trace.
Sulphur trioxide (SO_3)	5·39	28·67
Carbonic acid (CO_2)	·24	·10
Phosphoric acid (P_2O_5)	15·71	14·50
	99·71	100·35

No fluorine detected. A minute trace of chlorine present.

(4.) Light fluffy fungoid substance found in the Fairy's Grotto, Wilkinson's Cave, Left Imperial.

Two samples of this substance were received. The first, which weighed 1½ grammes, Guide Wyburd states, "was compressed into a small match-box, and would fill your hat in its natural state. It is so light that, when you blow at it, it falls off the roof and sides like snow." It is stated to occur in one cave only—that is, at the end of the Wilkinson Cave.

Analysis.	I	II
Moisture and combined water	1·88	1·48
Calcium carbonate ($CaCO_3$)	76·03	72·57
Magnesium carbonate ($MgCO_3$)	6·12	5·28
Strontium carbonate ($SrCO_3$)	trace	trace.
Alumina and ferric oxide (Al_2O_3 and Fe_2O_3)	1·46	1·94
Silica (Si_1O_2)	13·22	17·26
Phosphoric acid (P_2O_5)	·28	minute trace.
Organic matter	1·32	1·14
	100·31	99·67

The fungoid growth appears to be very rapid, for since the sample was received it formed in large quantities, and has the appearance of very fine wadding.

(5.) White pulverulent substance found in the Left and Right Imperial Caves.

Analysis.	I	II
Moisture at 200° C.	9·67	9·50
Loss from 200° C. to red heat	18·23	18·19
Alumina (Al_2O_3)	20·48	20·70
Ferric oxide (Fe_2O_3)	·18	·20
Lime (CaO)	trace	trace.
Magnesia (MgO)	do	do
Potash (K_2O)	8·89	9·01
Insoluble matter (sand, &c.)	1·07	1·12
Phosphoric acid (P_2O_5)	40·86	40·83
	99·38	99·55

A trace of ammonia detected. No fluorine, chlorine, or sulphur trioxide present. The analysis shows this deposit to be identical with the mineral minervite—a hydrous phosphate of alumina and potash, previously described by Adolphe Carnot.*

An analysis of minervite is given for comparison :—

Chemical Composition.

Moisture at 180° C.	23·70
Loss from 180° to redness	4·50
Aluminua (Al_2O_3)	18·59
Ferric oxide (Fe_2O_3)	·83
Lime (CaO)	1·40
Magnesia (MgO)	·33
Potash (K_2O)	8·28
Insoluble matter (sand)	4·35
Phosphoric acid (P_2O_5)	37·28
Ammonia (NH_4)	·52
	99·78

Traces of fluorine, chlorine, and sulphuric acid.

(6.) Nodular, greyish-coloured substance, found in the Imperial Cave.

Analysis.

Moisture at 100° C.	6·79
Combined water	3·52
Silica (SiO_2)	54·13
Alumina (Al_2O_3)	15·13
Ferric oxide (Fe_2O_3)	7·46
Lime (CaO)	absent.
Magnesia (MgO)	minute trace.
Potash (K_2O)	1·69
Soda (Na_2O)	·87
Phosphoric acid (P_2O_5)	10·63
	100·22

(7.) White saline substance, exuding from crevices in the Devil's Coach-house. A qualitative analysis proved this salt to be nitre (potassic nitrate). A small quantity of lime, magnesia, chlorine, and sulphuric acid were detected. The Author suggests that the phosphatic deposits were due, in the first case, to sedimentary silt, containing bones derived from the remains of animals, brought to their present location by an ancient river. The presence of large quantities of drift, fine river wash, red and white marls, in and above the caves, all tend to point in this direction.

(8.) A partial analysis of a greyish pulverulent substance taken from one of the caves (?), yielded as follows :—

Silica.	71·22	per cent.
Alumina	1·98	„
Phosphoric acid	7·63	„

* Journ. Chem. Soc., LXIX and LXX, p. 529.

† Journ. Chem. Soc., Abstract, 1892, II, 419, 577.

The small quantity of the mineral received prevented a more detailed analysis being made. Lime, and a trace of magnesia and organic matter, were detected. These substances differ so widely in composition, that with the exception of the the mineral previously described as Minervite in Gautier's* and Carnot's† papers; they are evidently alteration products formed as a secondary deposit in the caves.

Origin of the Phosphatic Deposits.

The solvent power of waters containing carbonic and organic acids, on limestone and clays, is generally well known, their action in dissolving these substances being more increased by their porosity, and extent of molecular surface through which these waters percolate.

Acidulated waters have also a marked solvent action on bones, apatite, &c., and take up a considerable quantity of phosphate of lime into solutions. Bischoff, in his "Chemical Geology," gives the following table showing the solubility of various phosphates in waters saturated with carbonic acid:—

	Water saturated with Co_2 parts.
Apatite dissolves in......................................	393,000
Apatite, after brisk agitation with the liquid, in ...	96,570
Artificial neutral phosphate, freshly precipitated, in	1,503
Same salt, after thorough drying in air, in...........	2,042
Burnt bones which had been exposed for several years, and absorbed carbonic acid	2,823
Fresh ox-bones, in shavings	4,610
Fossil bones, which had been buried at least thirty years	5,400 3,300

Bischoff also adds: "The quantity of carbonic acid required for the solution of the bones is by no means large, and in situations where carbonic acid is copiously and continuously evolved in putrefaction, this solution may take place rapidly."

The solvent action of water charged with carbonic acid is shown in the analysis of the water from the underground Caves River:—

(1) *Water from Underground River, Imperial Caves.*

	Grains per gallon.		In 1000 parts.
Total solid matter (dried at 220°F.) ...	13·160	...	0·1880
Free ammonia	·018 parts per 100,000		
Albuminoid ammonia	Nil. ,,		

Chemical Composition of Total Solid Matter:—

	Grains per gallon		In 1000 parts.
Calcium carbonate	9·949	...	0·1421
Magnesium carbonate	1·165	...	·0166
Strontium carbonate	trace	...	trace
Sodium chloride	·405	...	·0057
Silica	1·092	...	·0156
Nitrates, Sulphates, and Phosphates...	·549	...	·0078
	13·160	...	0·1878

* Journ. Chem. Soc., Abstract, 1893, II, pp. 419, 577.

† Ann. des Mines, 1895, 9, 8, 311-320.

The present deposits are of a secondary formation, due to the action of acidulated waters containing carbonic, organic acids, &c., which have percolated through the primary deposits of drift, silt, &c., thereby dissolving the bone material, and acting on the marls, dissolved a portion of the alumina and potash, the solution containing the phosphates having been re-deposited under conditions favourable for their separation.

It will be observed on referring to the analysis of the clay that it contains 5 per cent. of potash (K_2O). Nitrates are stated by various authorities to occur in cave formations, generally in the form of nitrate of lime; but in this case, it occurs combined with potash—thus tending to show the presence of quantities of organic matter, the nitrogen of which has combined with potash—probably derived from the marls and clays.

The origin of the deposits, however, and the conditions under which they have been redeposited is exceedingly interesting, and is open to wide discussion.

With regard to the extent of the deposits, it is impossible at present to form any opinion, owing to the difficulty of access to the Caves. It is probable, however, that the supply is very limited.

My thanks are due to Mr. Harper, Assistant Curator, Geological Survey Branch, for the second collection of phosphatic deposits exhibited at this meeting, also for notes made during his recent visit to the Caves.

The analysis of No. 2 was kindly made for me by Mr. H. P. White, Assistant Analyst in the Laboratory.

XII.—Notes and Analyses of some New South Wales Phosphatic Minerals and Phosphatic Deposits: By JOHN C. H. MINGAYE, F.C.S., Analyst.

(Read before the Australasian Association for the Advancement of Science, Saturday, January 8, 1898.)

(1.) Pyromorphite from Braidwood, near Little River :—

Chemical Composition.

Lead oxide (PbO)	69·40
Metallic lead (Pb)	6·57
Phosphoric acid (P_2O_5)	15·22
Vanadic acid (V_2O_5)	trace
Chlorine (Cl)	2·26
Ferric oxide (Fe_2O_3	·62
Lime (CaO)	trace
Insoluble in acids (Gangue)	4·67
Moisture	·86
	99·60

No gold or silver detected.

(2.) Apatite Crystals from Gordonbrook:—

Chemical Composition.

	I.	II.
Lime (CaO)	48·73	48·63
Calcium (Ca)	3·81	3·82
Phosphoric acid (P_2O_5)	41·22	41·11
Chlorine (Cl)	1·28	1·32
Fluorine (Fl)	2·86	2·92
Magnesia (MgO)	·19	·21
Ferric oxide (Fe_2O_3)	·76	·72
*Gangue	1·32	1·25
Water	·29	·29
	100·46	100·27

Mr. G. W. Card, A.R.S.M., F.G.S.,† has described the mineral as occurring in pinkish-white crystals, associated with an actinolitic substance, in narrow veins traversing granite.

(3.) Marsupial excrement.—This substance had the appearance of solid bitumen, and has on several occasions been sent for examination. I am informed that it is usually found in small solid masses in caves, or crevices between rocks. A partial analysis yielded as follows:—

Total nitrogen	2·24 per cent.
Equal to potassic nitrate	16·15 ,,
Phosphoric acid	·377 ,,
Insoluble matter (sand, &c.)	30·570 ,,

The whole of the nitrogen appears to be combined with potash, and the major portion of the phosphoric acid is in a soluble form.

(4.) Phosphatic deposit from Moruya Caves.—A partial analysis yielded as follows:—

Phosphoric acid (P_2O_5)	27·80 per cent.
Equal to tricalcic phosphate ($Ca_3P_2O_8$)	60·70 ,,
Calcium carbonate ($CaCo_3$)	3·29 ,,
Insoluble matter (sand, &c.)	11·68 ,,
Nitrogen, equal to ammonia	2·977 ,,

(5.) Phosphatic deposit from Moruya Caves.—A partial analysis yielded:—

Phosphoric acid (P_2O_5)	29·83 per cent.
Equal to tricalcic phosphate ($Ca_3P_2O_8$)	65·11 ,,
Calcium carbonate ($CaCo_3$)	8·18 ,,
Insoluble matter (sand, &c.)	·82 ,,
Nitrogen, equal to ammonia	·453 ,,

* The gangue was found to consist of silica, alumina, ferric oxide, lime, magnesia and a minute trace of phosphoric acid.

† Records Geol. Survey N. S. Wales, 1897, V, Pt. II, p.

(6.) Fine gem sand from the Tooloom Alluvial Gold-fields:—

Cerium oxide	6·20 per cent.
Thorium oxide	0·45 ,,
Lanthanum oxide } Didymium oxide }	4·30 ,,
Phosphoric acid	3·07 ,,

(7.) Coarse gem sand from the Tooloom Alluvial Gold-fields:—

Cerium earths as oxides	1·16 per cent.
Phosphoric acid	1·10 ,,

Both these samples consist largely of zircons. A small quantity of chrome iron-ore is also present, and a few dwt. of gold per ton.

XIII.—The Australian Geological Record for the Year 1897, with Addenda for the Years 1891–96: by R. ETHERIDGE, Junr., Curator of the Australian Museum, and W. S. DUN, Assistant Palæontologist.

ALFORD (C. J.):—
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Austr. Mining Standard, 1897, XIII, No. 447, p. 1918.

ALLAN (R.)—Report in connection with the Underground Plans of Ballarat West Mines. Pp. 3, maps. *Dept. Mines Vict.*, 1897.

ATKINSON (A. A.)—Report on the Inspection of Mines under the Coal Mines Regulation Act, in the Colony of New South Wales, for the Year ending 31st December, 1897. *Ann. Rept. Dept. Mines and Agric. N. S. Wales for* 1897, pp. 101–128, map.

ATKINSON (J. A.)—A Locality List of all the Minerals hitherto recorded from Victoria. *Proc. R. Soc. Vict.*, 1897, IX (*n.s.*), pp. 68–119.

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BATHER (F. A.)—*Haplocrinus Victoriæ* (n.s.), Silurian, Melbourne, and its Relation to the Platycrinidæ. *Geol. Mag.*, 1897, IV (4), pp. 337–345, pl. 15.

BEAL (L. O.)—Diamonds in the Gwydir Valley. *Austr. Mining Standard*, 1897, XIII, No. 426, p. 1576; No. 429, p. 1622; No. 431, p. 1652; No. 435, p. 1725; No. 439, p. 1787.

BERTRAND (C. E.)—Characteristiques d'un Charbon à gaz trouvé dans le Northern Coal-field de la Nouvelle Galles du Sud. *Comptes rendus Acad. Sciences*, 1897, CXXV, pp. 984–985.

BLATCHFORD (T.):—

Report of the Assistant Government Geologist. *Ann. Progress Rept. Geol. Survey W. Austr. for* 1897 [1898], pp. 51–63. Containing:—

1. Supposed Deep Lead at Kanowna, pp. 51–52, pl. 6.
2. The 25-mile Cement Leases, pp. 52–54.
3. Coolgardie Gold-field, pp. 54–64, pl. 7.

BOYD (W. Carr).—Journey from Western Australia to Warina, in South Australia. *Geogr. Journ.*, 1897, IX, No. 1, pp. 61–62, map.

BRADFORD (W.):—

Quartz Lodes in Ballarat West. *Austr. Mining Standard*, 1897, XIII, No. 431, pp. 1656–58.

The Steiglitz Gold-field, Victoria. *Austr. Mining Standard*, 1897, XIII, No. 444, pp. 1861–1863; No. 445, pp. 1878–1881.

Indicators. *Trans. Austr. Inst. Mining Eng.*, 1897, IV, pp. 120–123, 8 plates; *Austr. Mining Standard*. 1897, XIII, No. 462, pp. 2224–2225.

Neglected Gold-fields. No. I, Ararat. *Austr. Mining Standard*, 1897, XIII, No. 469, p. 2381; No. II, Ararat, *Ibid.*, No. 473, pp. 2465–2466.

BROKEN HILL.—The Silver Sulphides of Broken Hill. *Austr. Mining Standard*, Special Edition, 20th Jan., 1897. Pp. viii, 32.

BROWN (H. Y. L.):—

Reports on Arltunga Gold-field and Hart's Range, North-west of Alice Springs, and of the Frew River Country, &c. *S. Austr. Parl. Papers*, 1897, No. 1353, pp. 1–12, map and sections. [Reprinted in *Austr. Mining Standard*, 1897, XIII, No. 437, pp. 1756–1758; No. 438, pp. 1772–1774; No. 439, pp. 1788–1789.]

Record of the Mines of South Australia. The German Reef, with Notes and Plan. Pp. 7, map. (8vo. Adelaide, 1897. By Authority.) [Reprinted in *Austr. Mining Standard*, 1897, XIII, No. 470, pp. 2402–2403.]

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Mineralogical Notes, No. 5. *Records Geol. Survey N. S. Wales*, 1897, V, Pt. 2, pp. 66–67.

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CARD (G. W.) and DUN (W. S.)—Diatomaceous Earth Deposits of New South Wales. *Records Geol. Survey N. S. Wales*, 1897, V, Pt. 3, pp. 128–148, pls. 12–15.

CARNE (J. E.) :—

Notes on the General and Economic Geology of the Coast between Port Macquarie and Cape Hawke. *Records Geol. Survey N. S. Wales*, 1897, V, Pt. 2, pp. 53–64.

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PLATE XI.

Plan of Hargraves, N. S. Wales, showing five Lines of Saddle Reef,

Scale—400 feet to 1 inch.

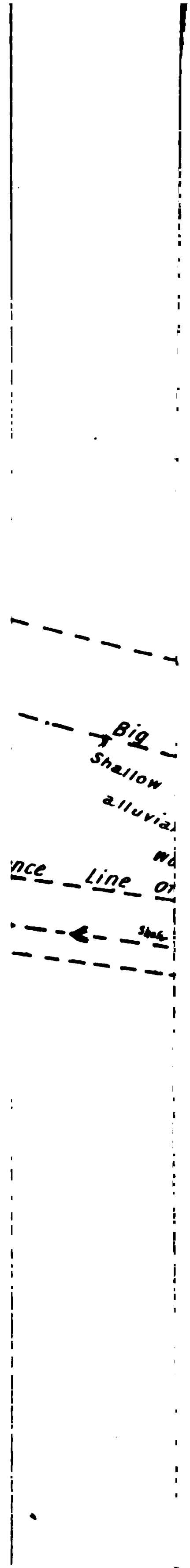
Big
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PLATE XII.

Sketch Section, from Louisa Creek to Woolachlan Creek, Hargraves.

Approximate Horizontal Scale—30 chains to 1 inch.

Sketch Section from Louisa Creek to Woolachlan Creek.

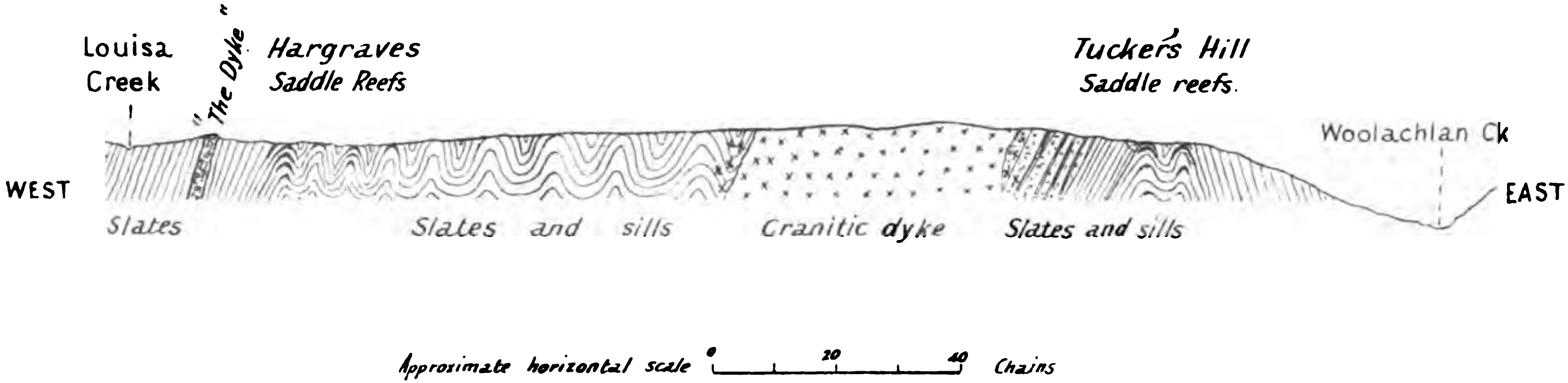

Photo-lithographed by W. A. Gullick, Government Printer, Sydney, N.S.W.

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PLATE XIII.

Photograph, showing the centre country of an anticlinal arch, west of Big Nugget Hill, Hargraves.

Photograph showing the centre country of an anticlinal arch, west of Big Nugget Hill.

PLATE XIV.

Photograph, taken on Big Nugget Hill, Hargraves, showing a portion of the cap of the Big Nugget Saddle Reef.

Photograph taken on Big Nugget Hill, showing a portion of the Cap of the Big Nugget Saddle Reef.

PLATE XV.

Cardiopteris c.f. polymorpha, *Goeppert.*

Fig. 1. Specimen, showing two large pinnules, opposite. Associated with *Rhacopteris inæquilatera, Goeppert.* From Mt. Hungry, near Paterson.

Fig. 2. Two adjoining pinnules, from the same locality as original of Fig. 1. Collected by Mr. C. Cullen.

Fig. 3. Single elongate pinnule, from Paterson. Collected by Mr. C. A. Sussmilch.

Fig. 4. Broader pinnule, from the same locality. Collected by Mr. J. E. Dobson.

Fig. 5. Two pinnules, isolated from a number of impressions. From the same locality; collected by Mr. C. A. Sussmilch.

Plate drawn from nature by Mr. F. R. Leggatt, natural size. Reproduced by Heliotype.

1

3

4

2

5

Frank R. Leggatt, del.

DEPARTMENT OF MINES AND AGRICULTURE, SYDNEY.

RECORDS

OF THE

GEOLOGICAL SURVEY OF NEW SOUTH WALES.

Vol. VI.] July, 1899. [Part 3.

XIV.—On the Corals of the Tamworth District, chiefly from the Moore Creek and Woolomol Limestones: by R. ETHERIDGE, Junr., Curator of the Australian Museum, Sydney.

[Plates XVI-XXXVIII.]

I.—Introduction.

THE following paper emanated from a wish expressed by Prof. T. W. Edgeworth David, B.A., and Mr. E. F. Pittman, Government Geologist, to be furnished with any tangible results that a study of the Palæozoic Corals of the Tamworth District, in N. S. Wales, might bring forth. It was undertaken without any personal knowledge, on my part, of the neighbourhood in question, or of its geology, and the opinions expressed are so with all diffidence and reserve. I merely wish to point out that the descriptions are actually those of the corals submitted to me.

The specimens form portions of three collections, viz., the Geological Survey of N. S. Wales, the Australian Museum, and the University of Sydney, and with a few exceptions were collected by Prof. T. W. E. David, and Mr. D. A. Porter, of Tamworth, who presented them to the respective cabinets in question. The remainder, with one exception, were obtained by Mr. T. Beedle, the exception being officially collected by Mr. W. Anderson, late of the Geological Survey of N. S. Wales.

The literature appertaining to the subject is all but *nil*, only one coral having previously been described with any certainty from around Tamworth, viz., *Diphyphyllum Porteri*, by myself. Prof. L. G. de Koninck, however, records one,

Syringopora auloporoides, De Kon., which, there is every reason to believe, was obtained at Moore Creek. He said of it—"a eté rencontrè à Moara Creek, au nord de Tamworth."* It is much to be regretted that my late friend was not supplied with fuller and more accurate information regarding the localities of the fossils forwarded to him by the late Rev. W. B. Clarke. For instance, at p. 71 of his work, he records *Cyathophyllum obtortum*, Ed. and H., from Moara Creek, "aux environs de Yass"! Again, at p. 77, he speaks of the occurrence of *Alveolites subæqualis*, Ed. and H., "à Mowara, dans le voisinage de la chaîne de Moonbi (Moonbi Range)"! At p. 80, *Favosites reticulata*, Blainv., is said to come from "Mowara" simply, and at p. 82 the same remark is appended to *Heliolites porosa*, Goldf. With these discrepancies surrounding them it does not seem profitable to further refer to the corals in question.

I have little doubt that Moara Creek, to the north of Tamworth, and Mowara in the Moonbi Range are one and the same locality, and are in fact simply Moore Creek, which runs from the Moonbi Range on the east to the Peel River on the west; and further that Moara Creek, near Yass, is simply a mistake. Mr. H. S. W. Crummer, of the Lands Department, was kind enough to look the matter up in the records of his office, and has arrived at the same conclusion; furthermore, Mr. D. A. Porter, of Tamworth, than whom no one has a better knowledge of the country round that town, does not know of any creeks bearing those names in the district in question. Similarly, Mr. John Mitchell, of the Technological College, Newcastle, and for many years resident at Bowning, is quite unacquainted with the names Moara or Mowara in the whole of the Yass District.

As to identification of the species: it has been the custom to identify our Lower Palæozoic Corals, as far as possible, with European and American species, chiefly the former, purely from macroscopic characters. From their peculiar condition of fossilisation—whereby silica, in one form or another, has entered so freely into their composition, as an agent of secondary replacement, at one time obscuring a feature, at another exaggerating it—my experience leads me to the conclusion that it is impossible to identify organisms, so open to alteration as Corals, with exotic species, with the exception of a few well-known and widely-distributed forms such as *Favosites gotlandica*, and *Heliolites porosa*, &c.

I have, therefore, adopted the principle, except in such cases as there can be little or no doubt about, of applying new names, accompanied by the best descriptions I could furnish, leaving those who may come after me, provided with larger opportunities, either to uphold the determinations, or rectify them.

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* Foss. Pal. Nouv.-Galles du Sud, Pt. 2, 1876, p. 76.

II.—Description of the Species.

GENUS DIPHYPHYLLUM, *Lonsdale*, 1845.

(Murchison's Geol. Russia in Europe, 1845, I, p. 622.)

Diphyphyllum Porteri, *Eth. fil.*

D. Porteri, Eth. fil., Rec. Geol. Survey N. S. Wales, 1890, II, Pt. 1, p. 19, t. 1, f. 7–11.

Loc.—"Tamworth" (*D. A. Porter*).

Diphyphyllum robustum, *sp. nov.*

(Pl. XXXII, Figs. 1 and 2; XXXVII, Fig. 2.)

Sp. Char.—Corallum fasciculate, in large masses. Corallites long, cylindrical, here and there in contact laterally, straight or slightly flexuous, with an average diameter of from eight to ten millimetres, and united at rare intervals by exothecal outgrowths. Walls thin; epitheca thin, with delicate, close, and slightly wavy transverse striæ, and more distant, very regularly rounded growth accretions; costæ when visible, rounded; exothecal outgrowths apparently very rarely developed. Septa well developed, straight, from forty-two to forty-six; the primaries about three millimetres long, or about one-third the diameter of the corallites, the secondaries from one-half to one-third the length of the primaries, the distal ends of the latter are free, and impinge slightly on the central tabulate area. Dissepiments straight, or slightly convex outwards in two or rarely three cycles, alternating with one another (in cross section), subdividing the interseptal loculi into oblong spaces; in vertical section forming two or three, usually two rows of markedly convex, or globular vesicles. Tabulæ complete or incomplete, of variable distance apart, one millimetre or less, to three tabulæ in the space of one millimetre; when complete without deflection at the circumference, when incomplete vesicular, the vesicles circumferential.

Obs.—This species is quite distinct from the other Tamworth form (*D. Porteri*); it is both larger, of a more vigorous growth, and has a greater septal and dissepimental development.

As regards its condition of fossilisation, the wall is in no way thickened, although the septa and dissepiments are to some extent so, the primordial laminæ in both being preserved as dark lines. There is no trace of any true inner mural investment.

The exothecal outgrowths appear to be very sparsely developed, but here and there the corallites are in contact laterally for longer or shorter distances, but in general terms the latter form loosely aggregated bundles.

The tabulæ when incomplete exhibit vesicles around the inner circumference of the visceral chambers.

D. robustum differs from the generic type, *D. concinnum*, Lonsdale,* by possessing a relatively much smaller amount of dissepimental tissue, and a larger number of septa, otherwise the two forms are nearly allied. It is also near to *D. arundinaceum*, Billings,† of the Corniferous Limestone of North America, *D. gracile*, McCoy,‡ and other large Devonian species.

In many places the tissue of the septa and dissepiments is replaced by chalcedonic quartz, such portions always appearing by ordinary transmitted light as opaque white lines or patches. The interseptal loculi and visceral spaces between the tabulæ are filled either with crystalline calcite, or the latter and crystals of quartz.

Loc. and Hor.—Moore Creek, near Tamworth (*T. W. E. David.*)—Moore Creek Limestone.

GENUS SANIDOPHYLLUM,§ *gen. nov.*

Gen. Char.—Corallum compound, or sub-fasciculate, composed of a great number of corallites united together by a series of persistent, exothecal, embracing, solid, plate-like platforms. Corallites as a rule widely separated, or occasionally partially united laterally, zaphrentoid in character, cylindrical and long. Septa of two orders, lamellar, plain, numerous, tetramerally disposed. An outer mural investment present only. Tabulæ present and variable in character. Dissepiments often vesicular. No columella. Gemmation calicular.

Sanidophyllum Davidis, *sp. nov.*

(Pls. XVI; XVII, Fig. 1; XIX, Fig. 7; XX, Figs. 4 and 5; XXXVIII, Fig. 2.)

Obs.—The compound corallum in this interesting fossil forms masses of very considerable extent, and when viewed from above presents the appearance of a number of isolated corallites of fairly large size, in consequence of the entombing matrix apparently separating them entirely from one another (Pl. XVII, Fig. 1). On examining the corallum, however, in a side view the fact is revealed that the corallites are all united at successive levels by a series of exothecal platforms that entirely surround each corallite, forming a series of superimposed, solid, although thin plates at given and very regular equidistant levels throughout the entire mass (Pl. XVI). I am informed by Prof. T. W. E. David, who collected the specimens, that hemispheric masses can be seen in the Moore Creek Limestone six feet wide by about two feet high.

The corallites are in general cylindrical and long, with a feebly-developed proper wall, and varying in transverse diameter from ten to twenty millimetres. In consequence of the bulging that takes place at the offsetting of the platforms the

* Murchison's Geol. Russia in Europe, 1845, I, p. 624.
† Nicholson, Pal. Ontario, 1874, I, p. 32, t. 6, f. 1.
‡ Brit. Pal. Foss, Fas. I, 1851, p. 88.
§ σανίς, ἴδος, a platform.

corallites in vertical section are hourglass-shaped, being quite free in their constricted portions (Pl. XVI). The distance apart of the corallites is somewhat variable, from half to three-quarters of an inch, although in a very few instances individuals were observed in close contiguity to one another. There also seems to be a well-developed epitheca, and coarse rounded accretion swellings.

The exothecal platforms are remarkably persistent, the persistence only equalled by the regularity of their superposition, the distance apart of one from the other being a trifle less than half an inch, although as much as one inch has been observed. On leaving the corallites these plate-like expansions incline upwards to some extent, and then assume either a horizontal or slightly undulating or rolling course (Pl. XVI, and Pl. XX, Fig. 4). They seem to be formed in each case by an outgrowth of the wall of a mature corallite, a new bud taking its rise from the old calyx, and soon attaining the same transverse diameter as the parent from which it sprung.

The septa are lamellar, from fifty to fifty-five in number, primary and secondary. The former are very long, straight or curved, and extending nearly to the centre of the visceral chambers; the latter are short, and proceed inwards but a limited distance (Pl. XX, Fig. 5). The septa are invariably more regular, and better developed on what I take to be the dorsal side, the cardinal quadrants being discernable and unequal, but the tetrameral symmetry of the counter quadrants is not so easily decipherable. The dorsal septum in all my sections is long, like the alar septa, extending nearly to the centre of the visceral chambers, but it does not seem to rest in a fossula; indeed, I have failed to distinguish this organ with any certainty, except perhaps in a young corallite. The septa of the cardinal quadrant on nearing the centres of the visceral chambers coalesce in groups, but do not revolve around an imaginary axis, nor in any way simulate even a pseudo-columella, but a central vesicular (tabulate) area of greater or less extent is left on which they do not quite impinge.

The septa of the counter quadrants, immediately on leaving the wall, seem to loose their individuality, and become more or less comingled with, or lost in the cut edges (in section) of the dissepimental vesicles.

In Plate XVII, Fig. 1 (lower end) is partially shown the upper surface of a platform around a corallite, in other words the edge or margin of an old calice, but on this the septa are continued in the form of gradually widening bands, as in *Chonophyllum* and *Vesicularia*, Rom.* How far these septal bands extend, whether completely over the surface of a platform, or only for a short distance around a corallite, I am unable to say, but probably the former.

* This name was preoccupied, but S. A. Miller proposes in its place that of *Cystiphorolites*.

The dissepiments in some of the interseptal loculi of the cardinal quadrants are normally developed, especially in the circumferential region, but on approaching the distal ends of the primary septa they become irregular. Those of the counter, or ventral side, are so much so as to give rise to the appearance of cut edges (in section) of regular vesicular tissue.

The tabulæ are very irregular, so much so, indeed, as to hardly merit that title, occasionally extending across the central area, or only partially so, forming large vesicles and becoming so intimately associated at the circumference of the corallites, where they are deflected downwards, with the dissepimental vesicles, that it is difficult to say where one begins and the other ends (Pl. XX, Fig. 4).

As regards the microscopic structure :—The primordial septa are only occasionally preserved as a thin light line in otherwise dense and dark sclerenchyma, the general tissues being either of this colour, or of a cloudy white tint. The thickening that has taken place as a secondary process is comparatively slight. The exothecal platforms almost invariably consist of cloudy sclerenchyma, and are never vesicular. The tissue of the vesicles, both dissepimental and tabular, is either dense dark sclerenchyma, or represented by lines of very small aggregated crystals of calcite. The interseptal loculi and the tabular vesicles of the central area are lined with granular calcite, and the centres filled by crystalline calcite with cleavage, or the latter may be replaced by crystalline quartz, but there is no trace of chalcedonic quartz. The fusing together of the septal bases into a dense mass of cloudy sclerenchyma renders it very difficult to say whether or no a true wall existed, but it seems to have very much the character of the investment in *Streptelasma*, in which case it would be simply a false wall.

Plate XX, Fig. 4, represents a vertical section taken nearly in the centre of a corallite, whilst Pl. XIX, Fig. 7, is that of one much nearer the circumference. In the former there appears to be a series of circumferential vesicles of a transversely elongate shape, surrounding the central tabulate area. This section also exemplifies the highly vesicular nature of the tabulæ—if they can be called tabulæ in the strict sense of the word—complete diaphragms being the exception. Here and there a line of demarcation between the vesicular tabulæ and the circumferential or dissepimental vesicles can be distinguished, but in other places they seem to merge into one another; on the other hand in a third instance the vesicular tabulæ appear to extend quite to the wall. The second figure quoted represents a section that has passed through the septal zone, and displays the mixture of complete and vesicular dissepiments. Both sections render it quite clear that the platforms were solid structures, and in no way either vesicular or tubular.

The presence of the exothecal outgrowths recalls to mind the genus *Eridophyllum*, which some writers unite with *Diphyphyllum*. The corallites in *Eridophyllum* are said to be united by subradiciform processes, but between these and the

platforms in *Sanidophyllum*, there is this very important difference—that in the former the subradiciform processes unite contiguous corallites only, and at opposite points in their circumference, whilst in the latter, the whole is surrounded as it were by a frill, which extends to all adjacent corallites, uniting them into a compound corallum by equidistant superimposed layers.

Congeneric possibly with *Sanidophyllum Davidis* is, I believe, a coral from the Prussian Silurian, that Mr. H. Weissermel has described as a variety of Dybowski's *Spongophyllum contorti-septatum*, under the name of var. *præcursor*,* but Weissermel refers Dybowski's species to *Endophyllum*. The general structure of Weissermel's variety is almost identical with that of the proposed new genus, although there are satisfactory specific differences, such as those of the peripheral vesicular tissue, the tissue of the vesicular tabulæ, and the much greater contiguity of the corallites. On the whole it seems to me that we perhaps have here a second species of *Sanidophyllum*—*S. præcursor*, Weissm.

The arrangement of the septa in *Sanidophyllum* appears to be on the plan of the *Zaphrentis* group of the Cyathophylloidea, although all the features in the anatomy of the newly proposed genus are not as clear as they might be. Nevertheless, we notice that the septa are well and more or less tetramerally developed, extending nearly to the centres of the visceral chambers; there is no columella or pseudo-columella. The characters of *Zaphrentis* that we do not see are the fossula, and the complete non-vesicular tabulæ; and lastly, I presume the corallum falls within the meaning of the word compound, which is certainly not the case in *Zaphrentis*. In the presence of the successive floods a possible resemblance may be found in *Astræophyllum*, N. & H., but the latter is also furnished with a columella.

Two other corals yet remain to be referred to—*Blothrophyllum cæspitosum*, Rom.,† and *Heliophyllum colligatum*, Billings.‡ Of the first of these Rominger says—"The clustered stems [corallites] become attached to each other by their acute annular edges"; and of the second he remarks—"The stems [corallites] are regularly articulated by deep constrictions, in which constricted parts they are free. In alternation with these constrictions the calyces become broadly expanded at certain levels, coincident in all the tubes [corallites] of the colony, and join with their margins under polygonal outlines in a continuous floor of astræiform aspect, . . . and from the centre of each of the old calices a new calyx grows with a contracted base rapidly dilating above, in order to meet the others in a common floor, which contractions and expansions follow each other in constant succession."

Although at the first glance both these corals would appear to possess points in common with *Sanidophyllum*, such is, however, only the case to a limited extent,

* Zeit. Deuts. Geol. Gesellschaft, 1894, XLVI, Heft 3, p. 603, t. 48, f. 2a–3b.
† Report Geol. Survey Michigan. Lr. Peninsula, 1873–76, III, Pt. 2, p. 114.
‡ *Ibid.*, p. 127, t. 38, f. 3. (= *Diphyphyllum*, Rominger.)

thus:—In *B. cæspitosum*, the dilatations of the calice margins are very irregular, not at the same level throughout the corallum, and do not connect the various corallites composing it as regularly superimposed and equidistant floors. In *Sanidophyllum* the corallites are certainly not of the nature of "invaginated cups," nor are they "attached to each other by their acute annular edges"; furthermore, the tabulæ in *B. cæspitosum* are far more complete than in the Australian coral, at the same time there is an undoubted resemblance between the two forms.

As regards *Heliophyllum colligatum* there is an obvious similarity in the union of all the corallites, by the broadly expanded circumferences of the calices "at certain levels, coincident in all the tubes [corallites] of the colony," but the striated and denticulated septa* otherwise demonstrate it to be a *Heliophyllum*.

Named in honour of Prof. T. W. E. David, B.A., who discovered this interesting coral.

Loc. and Horizon.—Moore Creek, one mile north of Tamworth (*T. W. E. David.*)—Moore Creek Limestone.

GENUS SPONGOPHYLLUM, *Edwards and Haime*, 1851.†

(Polyp. Foss. Terr. Pal., 1851, p. 425.)

Spongophyllum giganteum, *sp. nov.*

(Pls. XX, Figs. 1–3; XXXVIII, Fig. 3.)

Sp. Char.—Corallum compound and very large. Corallites prismatic, large, usually hexagonal, in close contact, often attaining a diameter of from twenty-eight to thirty millimetres. Walls strong, but not greatly thickened, and amalgamated. Circumferential zone in a fully matured corallite as much as five millimeters wide, highly vesicular, the vesicles large, lenticular, convex upwards, oblique and sloping inwards towards the centre, insensibly passing into an intermediate septal zone. Septa of the intermediate zone from forty-five to fifty, without any marked division into primary and secondary; interseptal loculi narrow, divided by complete transverse dissepiments, either alternating with one another in contiguous loculi, or on the same line, when they form cycles throughout the whole zone. Central area from five to eight millimetres wide, tabulate, the tabulæ very plentiful, exceedingly close, rarely complete, but as a rule highly vesicular, the vesicles small.

Obs.—This coral forms a fine and well marked species, and is allied to *S. bipartitum*, mihi, but is of a much larger habit, possesses fully double the number of septa, and has a wider central area. Of the Eifelian species described by Schlüter, it resembles only *S. Kunthi*,‡ but is a very much larger species.

* Nicholson, Pal. Ontario, 1874, Pt. 1, p. 28.

† Emended Schlüter.

‡ Verhandl. Nat. Vereines preuss. Rheinl.-Westf., 1881, t. 7, f. 4 and 5, t. 8, f. 1 and 2.

In worn specimens the tissue of the circumferential zone weathers out as large convex vesicles; the tissue of the septal zone as oblique vesicles, whilst the central area from the highly irregular and vesicular nature of the tabulæ appears as a mass of thin weathered-out plates, but more often this central area is represented by a hollow tube-like cavity, from the entire disappearance of the vesicular tabulæ, extending from one end of a corallite to the other. Under these circumstances the coral presents a very marked and rugged appearance, one when once seen, not easily forgotten.

The mineral structure varies somewhat in different specimens. One is practically calcareous throughout, all the cavities being filled by crystalline calcite with cleavage. Others, on the contrary, exhibit the vesicular cavities in the same individual similarly filled, or lined with chalcedonic quartz, and a crystalline quartz nucleus.

Loc. and Horizon.—Moore Creek, near Tamworth (*T. W. E. David.*)—Moore Creek Limestone.

GENUS ACTINOCYSTIS, *Lindström*, 1882.

Actinocystis, Lindström, Öfv. K. Vet.-Akad. Förhandl. Stockholm, 1882, XXXIX, No. 3, p. 21.

Spongophylloides, Meyer, Schriften Phys.-Ökonomischen Gesell. Konigsberg, 1881 [1882], XXII, p. 109.

Actinocystis, Lindström, Bihang K. Svenska Vet.-Akad. Handlingar Stockholm, 1896, XXI, Afd. 4, No. 7, p. 47.

Actinocystis ? cornu-bovis, *sp. nov.*

(Pls. XXI, Figs. 1 and 2; XXXVIII, Fig. 1.)

Sp. Char.—Corallum simple, straight, or somewhat curved, large, height of a medium sized specimen four inches, and diameter one and a half inches, height of largest specimen six inches, diameter two and a half inches. Epitheca thin, concentrically and finely ridged. Wall very thin. Outer zone of variable width, at least half an inch wide, composed of very large lenticular vesicles. Intermediate septate zone containing more than fifty septa, probably from fifty-five to sixty; septa slightly flexuous, and at their distal ends lost in a cycle of vesicles; interseptal loculi occupied by a large number of irregular dissepiments, so irregular as to constitute an interseptal vesicular tissue. Central area tabulate, and not impinged on by the septa; tabulæ concave, and when cut in horizontal section presenting the appearance of very large vesicles.

Obs.—According to Dr. Lindström's recent figures of the type of his genus, *Actinocystis Grayi*, Ed. and H., sp., the present coral differs therefrom by the possession of a tabulate centre, and it may perhaps be necessary to ultimately remove it. *Actinocystis* is founded on *Cystiphyllum Grayi*, Ed. and H., the septa according to Lindström, being developed only at the bottom or middle of the calice, and surrounded by a circumferential zone of vesicular tissue. *A. ? cornu-bovis* differs in a similar way from *A. terra-reginæ*, mihi,* there being no tabulate area in the latter.

Dr. F. Frech has figured† a coral from the German Devonian under the name of *Actinocystis Goldfussi*, Ed. and H. sp., in which the dissepimental vesicular tissue resembles that in *A. ? cornu-bovis*, and in addition possesses a wide central tabulate area, although the circumferential vesicular zone of the latter is absent. Whether Frech's coral is *Cyathophyllum Goldfussi*, Ed. and H., or not, it is impossible for me to say. He quotes in his synonomy, *Plasmophyllum Goldfussi*, Schlüter,‡ which is certainly founded on Edwards and Haime's species, but as Dr. Schlüter in a later publication§ makes no remark on the subject, I much doubt it, particularly as the longitudinal section given by Frech is that of an elongate cylindrical coral, whereas *Cyathophyllum Goldfussi* as figured by the French authors, and again under the name of *Stereophyllum Goldfussi* by Schlüter, in the later publication referred to, is a short turbinate form.

The tissues are slightly thickened, but not silicified, and in many cases the primordial lines of both the septa and dissipments are of a lighter colour than the slightly thickened wall. The vesicles of the outer area are filled, some with granular calcite, some with crystalline calcite with cleavage, some with quartz crystals, or some even with a mixture of any two, or all of these minerals. The same holds good for the infilling of the dissepimental vesicles in the intermediate area, but here perhaps the quartz crystals predominate over the others, and there are notable instances in which a group of quartz crystals exists surrounded by a circumferential ring of chalcedonic quartz. The tabular vesicles are more often filled with granular quartz.

Loc. and Horizon.—Moore Creek, near Tamworth (*D. A. Porter.*)—Moore Creek Limestone; Seven miles north-west by north of Tamworth (*D. A. Porter.*)—Woolomol Limestone.||

* Proc. Linn. Soc. N. S. Wales, 1894, IX (2), p. 524, t. 39, f. 1 and 2.

† Dames and Keyser's Pal. Abhandlungen, 1886, III, Heft 3, p. 107.

‡ Sitz. Niederrheinischen Gesells. Bonn, 1885 (Jan. 5th), p. 10.

§ Abhandl. Geol. Specialkarte preuss., 1889, VIII, Heft 4, pp. 78-81.

|| Prof. David says this distance and direction would just about fetch the Woolomol Limestone at its typical outcrop in the Parish of Woolomol.

GENUS MICROPLASMA, *Dybowski*, 1874.

Microplasma, Dybowski, Archiv. Naturkunde Liv.-Ehst.-Kurlands Dorpat, 1874, V, Lief. 4, p. 508.

? *Diplochone*, Frech, Dames and Keyser's Pal. Abhandl., 1886, III, Heft 3, p. 105.

Microplasma parallelum, *sp. nov.*

(Pls. XIX, Figs. 1 and 2; XXX, Figs. 1 and 2.)

Sp. Char.—Corallum fasciculate, in the form of large hemispherical masses. Corallites long, cylindrical, parallel, close, often in contact but never fused, at times slightly flexuous, generally resembling a series of tubicolar worm cases; section circular; diameter uniformly two millimetres. Epitheca well developed, regularly annulated by rounded growth swellings; costæ not visible. Wall thick, solid. Septa lamellar, from twenty-five to thirty, extending inwards for half the diameter of the corallites, thin, delicate and slightly flexuous; dissepiments not visible. Central area occupied by a mass of irregular vesicular tissue. Gemmation parietal.

Obs.—At first sight *Microplasma parallelum* has the appearance of a *Syringopora*, but thin sections prepared for the microscope soon dispel this idea.

Microplasma is both a Silurian and Devonian genus, but attains its chief development in rocks of the former age; very few species have so far been described.

In its method of growth, the present species approaches *M. Schmidti*, Dyb.*, but there is no trace of the connecting processes of the latter. The irregularity of the central vesicular tissue places it near not only to the coral just mentioned, but also *M. lovenianum*, Dyb.,† although the septal system of the new form is quite distinct from that of either; both these are Silurian corals. From the principal Devonian species, *M. (Diplochone) fractum*, Schlüter‡, the new coral differs entirely, both in form, mode of growth, and in the condition of its septa. The latter appear to be rather long for a *Microplasma*, but perhaps not longer in proportion than those of *M. pectiniseptatum*, Dyb.§; and are even still more akin to those of *M. Munieri*, C. Barrois‖, a Spanish Devonian species.

I have not been able to trace the circumferential series of inclined vesicles seen in some species.

The corallum in the specimens examined microscopically is entirely calcareous, all the cavities being filled with crystalline calcite with cleavage.

Loc. and Horizon.—Moore Creek, near Tamworth (*T. W. E. David.*)—Moore Creek Limestone.

* Archiv. Naturkunde Liv.-Ehst.-Kurlands Dorpat, 1874, V, Lief. 4, p. 511, t. 5, f. 3.
† *Ibid.*, p. 510, t. 5, f. 4*a*.
‡ Abhandl. Geol. Specialkarte preuss., 1889, VIII, Heft 4, p. 84, t. 6, f. 4-8.
§ *Loc. cit.*, p. 512, t. 5, f. 6.
‖ Mém. Soc. Geol. Nord, 1882, II, p. 211, t. 8, f. 4*d*.

GENUS FAVOSITES, *Lamarck*, 1812.

(Cours de Zool., 1812; Hist. Anim. sans Vertèb., 1816, II, p. 204.)

Obs.—I have experienced the greatest difficulty in identifying the Favosites of the Tamworth area, and I may add those of Australian rocks in general. This arises chiefly from the absence of good microscopic descriptions of the species established by the older European and American writers, except in the case of a very few of the best known forms (and even these are often rendered difficult of comprehension by reason of the discrepancies that exist in the respective descriptions); and, in a minor degree, from the personal want of microscopic sections of authenticated species of the countries named.

I have tentatively reduced the non-branching Tamworth Favosites to three species, two varieties, and an indicated species. A very considerable number of slides have been prepared from examples in the Geological Survey, Australian Museum, and University Class collections. In the meantime the following determinations must be accepted for what they are worth, but the characters assigned are those of the actual fossils before me.

a. Massive Species.

Favosites gotlandica, *Lamarck.*

(Pls. XXII and XXIII.)

Favosites gothlandica (Lamarck), Nicholson, Tab. Corals Pal. Period, 1879, p. 46, t. 1, f. 1–6.

Favosites gothlandica, Nicholson and Etheridge, Junr., Ann. Mag. Nat. Hist., 1879, IV (5), p. 219.

Favosites Goldfussi, McCoy, Prod. Pal. Vict., Dec. IV, 1876, p. 15, t. 35, f. 1 *a–d*.

Sp. Char.—Corallum compound, either in spheroidal or hemispherical masses. Corallites prismatic, polygonal—triangular to heptagonal—but the pentagonal and hexagonal forms predominating, from two to two and a half millimetres in diameter; young corallites triangular and quadrangular, intercalated amongst the older. Walls only slightly thickened by secondary deposit; primordial wall usually visible as a central line in the wall substance; longitudinal mural striations not observed. Mural pores of medium size and impressed, no trace of elevated rim-like margins, two to three on each angular corallite face, alternately placed. Septa numerous, and usually present, as well-developed short spines, but irregularly spaced as regards one another in the same cycle; seldom less than than twelve and as many as sixteen in a cycle. Tabulæ numerous, usually complete, but occasionally incomplete and inosculating; generally horizontal—*i.e.*, at right-angles to the longer axis of their respective corallites, at times slightly oblique; average distance apart, from three-quarters to one millimetre. Old visceral chambers transversely oblong.

Obs.—Forms answering to the above description are tolerably common in the Lower Palæozoic rocks of New South Wales and Queensland, and I have assumed them to be *Favosites gotlandica*. The reasons for uniting *F. gotlandica* and *F. Goldfussi*, so far as Australian examples are concerned, have already been given by the late Prof. Alleyne Nicholson and myself. Previous to our work, however, Prof. McCoy had separated examples from the Buchan Limestone of Victoria, as the latter species, thus following Edwards and Haime. These Victorian corals are very near, indeed, to our Tamworth forms, possessing similar and numerous mural pores, moderately close tabulæ, and the same unequally spaced septa.

In only one instance is the corallum complete, and that is spheroidal; the others are simply portions of large colonies that appear to have been hemispherical. The first lacks an epitheca on the under surface; but presuming this surface to be moderately complete, it is at the sides rather hollow, with a central projecting portion at the base, that may have been a peduncle of attachment to some foreign body. This specimen is three inches along both diameters, and one and three-quarter inch high. The hemispherical specimens have a markedly radiate arrangement of the corallites, and although only portions of colonies are little short of five inches square.

The corallites in none of the individual colonies exhibit any tendency to become round, but are all distinctly angular, the younger being invariably either triangular or quadrangular, and distributed at intervals among the older. As regards the size of the corallites, they appear to be intermediate between examples from the English and Gotland Wenlock, cited by Prof. Alleyne Nicholson, the former being one line, and the latter one and a-half to two lines; here they vary from one to one and a half line or two to two and a-half millimetres approximately. None of our specimens exhibit the longitudinal lines on the exterior faces of the corallite walls, nor the transverse striæ which indicate the position of the tabulæ within, that are visible on those of *F. gotlandica* from other parts of the world.

The primordial wall is visible quite as distinctly as represented in the beautiful figures of *F. gotlandica* by G. von Koch,* and does not exhibit any trace of a bilaminar structure. This primordial wall is held by Mr. H. M. Bernard not to be the conjoined wall of separate and contiguous corallites, but to arise from the meeting and fusion of the septa.† If such is the cause, whenever the primordial wall is present, the primordial septum should be also, but as a matter of fact the latter is not in evidence in any of the Tamworth *Favosites*.

The septa are very conspicuous, and assume the appearance of blunt spines, not tubercles, and exhibit a strange inequality in their distance apart in the same cycle. A similar feature is figured by Penecke in a Devonian species, *F. eifelensis*,

* Palaeontographica, 1883, XXIX, Lief 5 and 6, t. 2, f. 1-7.
† Journ. Linn. Soc. (Zool.), 1898, XXVI, No. 17, p. 502, t. 33, f. 4.

Nich.,* and by Nicholson in *F. Forbesi*, Ed. and H.† Throughout the whole of the Australian *Favosites* that have come under my notice, great variability seems to exist in the preservation of the septal spines. Although, as before said, all the corals now under consideration possess them, on the other hand, out of the numerous specimens from Queensland examined by Prof. Alleyne Nicholson and myself, only one did so. I have also many examples from other N. S. Wales and Queensland localities, evidently belonging to the present species, that are in the same condition.

The tabulæ are commonly horizontal, but occasionally oblique, seldom inosculating, although now and then arched upwards to a slight extent. In a few rare instances I have observed, in sections, the peripheral bending down which imparts to the upper surfaces of the tabulæ a plicated or crumpled structure. On the other hand, the appearance of perforations passing vertically through the tabulæ, arising from this, and figured by Prof. Alleyne Nicholson‡ in an American example, were not detected in the Tamworth corals.

Again, unlike those of the Buchan *Favosites*, the mural pores are simply impressed, and do not possess elevated rim-like margins.

The mineral structure varies a good deal throughout a corallum. The tubes may be filled—(*a*) wholly with crystalline calcite; (*b*) wholly with crystalline quartz; (*c*) with a crystalline calcite lining, and a crystalline quartz centre, both of variable width, or sometimes intimately mixed: (*d*) with a crystalline calcite lining, and a chalcedonic quartz centre. The wall tissues are usually dense, but are here and there interrupted by chalcedony blebs, followed by a lining of crystalline calcite and a central infilling of quartz crystals.

Loc. and Horizon.—Parish of Woolomol, near Tamworth (*T. W. E. David.*)—Woolomol Limestone; Moore Creek, near Tamworth (*T. W. E. David.*)—Moore Creek Limestone.

Favosites basaltica, *Goldfuss*,§ var. moonbiensis, *var. nov.*

(Pls. XXIV, Figs. 1 and 2; Pl. XXIX, Fig. 2)

Char.—Corallum compound, large, oval, compressed. Corallites prismatic and polygonal—quadrangular to heptagonal—but the pentagonal and hexagonal forms predominating, one millimetre in diameter, and in the mature state very constant in size. Walls to a slight extent thickened by secondary deposit; primordial walls visible here and there. Mural pores of medium size, in one row on each angular face of a corallite, continuous in one line, not alternating, or zig-zag,

* Jahrb. K. K. Geol. Reichsanstalt, 1894, XLIII, Heft 3 and 4, t. 9, f. 5.
† Tab. Corals Pal. Period, 1879, t. 1, f. 7.
‡ *Loc. cit.*, t. 1, f. 2.
§ Petrefacta Germaniæ, 1826, I, p. 78, t. 26, f. 4.

depressed, and without elevated rims or margins. Septa not recognisable. Tabulæ numerous, generally complete, horizontal or slightly oblique, at times a trifle convex; at rare intervals incomplete and inosculating; four or five in the space of one millimetre, opposite or sub-opposite in contiguous corallites. Old visceral chambers shallow, transversely oblong.

Obs.—This has proved a very difficult form to determine, and although generally resembling the last species, I feel constrained to separate it on account of the much smaller and very uniform size of the corallites, the uniserial arrangement of the mural pores, and the very much more numerous and closer set tabulæ. The difference in size of the corallites is sufficiently marked to at once attract even the naked eye.

Rather than raise this to the rank of a species I am content to provisionally regard it as a variety of the European *F. basaltica*, Goldfuss. I prefer to say provisionally, as I am not personally acquainted with the microscopic characters of the latter.

Without entering on the debatable question of the validity of *F. basaltica* as a species, a point that was some years ago admirably discussed by Prof. Alleyne Nicholson,* I shall content myself by quoting his later opinion,† expressed in the following words:—"With regard to *F. basaltica*, Goldf., which resembles *F. gothlandica* in general features, but is stated to possess uniserial mural pores, I can express no definite opinion, for I have seen no specimens with this character. Unquestionably, if it were shown that there existed a species of *Favosites* in other respects like *F. gothlandica*, but *uniformly* possessing but a single row of pores on each of the prismatic faces of the corallites, there would be good grounds for regarding this as a distinct species."

In the present instance we have a form that uniformly possesses a single row of mural pores on each prismatic corallite face, and unless otherwise differing from *F. basaltica*, fulfilling the requirements necessary to bring it within the compass of that species. The walls are of one uniform texture, the primordial hardly ever visible, and are slightly thickened. No trace of septa throughout the whole of the specimens.

At each angle of a corallite a light clear spot is visible in the wall substance, but on a vertical examination there is not the slightest trace of any structure after the nature of an acanthopore (Pl. XXIV, Fig 2).

The tabulæ are either opposite or sub-opposite in contiguous corallites, and are invariably unthickened.

The whole of the visceral chambers are filled with crystalline calcite with cleavage.

Loc. and Horizon.—Beedle's Freehold, near Moonbi, north-east of Tamworth (*T. Beedle.*)—Moonbi Limestone.

* Pal. Ontario, 1874, I, p. 47.
† Tab. Corals Pal. Period, 1879, p. 52.

Favosites basaltica, *Goldfuss*, var.

salebrosa, *var. nov.*

(Pls. XXI, Figs. 3–5; XXVII, Figs. 1 and 2.)

Char.—Corallum compound, massive, with a rough and hackly appearance. Corallites small, prismatic and polygonal—quadrangular to hexagonal—but pentagonal predominating; often rendered irregular in outline in consequence of thickening, then becoming somewhat cylindrical, one half millimetre in maximum diameter. Walls thickened, particularly at the angles of junction of the corallites. Mural pores large, uniserial in the centre of each prismatic face of a corallite, about three-quarters of a millimetre apart, margins depressed, without elevated rim. Septa not recognisable. Tabulæ complete, unthickened, distant about three-quarters of a miliimetre apart, or two in the space of one and a half millimetres; usually horizontal, occasionally oblique, seldom curved, never inosculating, opposite or subopposite. Old visceral chambers nearly square, as a rule, the vertical diameter perhaps a little greater than the transverse.

Obs.—We again have before us a uniserially pored form, the character being a constant one, but as compared with the var. *moonbiensis*, possessing distant tabulæ. The corallities are much reduced in diameter as compared with those of the latter.

In weathered examples the surface of the corallum assumes a rough hackly appearance, somewhat similar to that seen in *F. occidens*, Whitf.*

Whatever may be the true specific identity of this coral, there can be little doubt of its distinctness from those that have gone before, but of the two, it is more allied to the var. *moonbiensis*, than to *F. gotlandica.*

Some of the visceral chambers are wholly filled with crystalline calcite, others with the latter mineral as a peripheral lining only, and a crystalline quartz centre.

Loc. and Horizon.—Parish of Woolomol, near Tamworth (*T. W. E. David.*) —Woolomol Limestone.

Favosites squamulifera, *sp. nov.*

(Pl. XXXVIII, Figs 4 and 5.)

Sp. Char.—Corallum compound, massive. Corallites semi-prismatic and sub-polygonal—irregularly pentagonal and hexagonal—irregular in size, but with an average diameter of one millimetre, or rather less. Walls thick, much altered. Mural pores small, in a single vertical series on each prismatic face of a corallite, depressed, without elevated margins. Septa not observed. Tabulæ numerous, complete and incomplete; the former either horizontal or slightly oblique, from

* Geol. Wisconsin, 1882, IV, p. 313, t. 23, f. 6 and 7.

three to four in the space of one millimetre, the latter consisting of squamulæ—*i.e.*, horizontal or oblique, more or less leaf or tongue-like lamellæ, dispersed between the former, and projecting from the corallite walls, which are rendered rough and rasp-like by their presence.

Obs.—The presence of squamulæ between the regular tabulæ removes this coral from the typical *Favosites*, and allies it to those forms for which Messrs. Edwards and Haime constituted the genus *Emmonsia*,* typified by *F. hemisphericus*, Y. and S. Allied only, because Prof. Alleyne Nicholson has remarked that, in addition to the *Emmonsia* form of tabulæ, consisting of "thin, flexuous, close-set laminæ, which for the most part only extend across about a third or a half of the total diameter of the tube," there is another section of *Favosites* in which, "in addition to, or in the absence of complete tabulæ, the inner surfaces of the tubes are rendered rough by the presence of numerous horizontal projecting lamellæ, which extend only a short distance into the visceral chambers, and which often have a more or less leaf-like or tongue-like character."† It is to this second section that the present coral seems most nearly allied, the presence of these squamulæ being a feature strongly indicative of a Devonian age, although they occur in at least one Upper Silurian species, viz., *F. Forbesi*, Ed. and H.‡

* The whole appearance of *F. squamulifera* forcibly reminds one of that of *F. hemisphericus*, Y. and S., and it probably represents the latter in our rocks.

Very instructive figures of these imperfect diaphragms, and the manner in which they sometimes inosculate, were given by the late Prof. James Hall in his illustrations§ of the structure of *F. epidermata*, Rominger; indeed his Fig. 12, of the reference cited below, might well stand for an illustration of our fossil.

Authors are much divided in opinion as to the value of *Emmonsia* as a separate genus, and I feel constrained to agree with Profs. James Hall and Alleyne Nicholson in rejecting it as such; for, in the words of the latter, "some of the tubes have the irregular and incomplete tabulæ of *Emmonsia*, while others have the regular and complete tabulæ of the type forms of *Favosites*—the same tube sometimes exhibiting both these conditions in different parts of its course—is quite sufficient to show that the separation of *Emmonsia* as a distinct genus cannot be carried out in practice."||

Loc. and Horizon.—"Tamworth" (*D. A. Porter*). The lithological character of the specimens is that of the Woolomol Limestone corals.

* Polyp. Foss. Terr. Pal., 1851, p. 246.
† Tab. Corals Pal. Period, 1879, p. 41.
‡ Tab. Corals Pal. Period, 1879, p. 42.
§ Ill. Dev. Foss.: Corals Up. Helderberg and Hamilton Groups, 1876, t. 12, f. 12, 13.
|| Tab. Corals Pal. Period., 1899, p. 41.

Favosites multitabulata, *sp. nov.*

(Pls. XVIII, Fig. 6; XXVI.)

Sp. Char.—Corallum compound, massive. Corallites prismatic and polygonal—quadrangular to heptagonal—but principally hexagonal, from three-quarters to one millimetre in diameter; young corallites quadrangular. Walls slightly thickened, the primordial occasionally visible as a faint dark line. Mural pores in two alternating series on each prismatic face of a corallite, moderately large, impressed, no raised margins. Septa spiniform, short, numerous.. Tabulæ very numerous and exceedingly close, from five to eight in the space of one millimetre, complete, horizontal, opposite or sub-opposite in contiguous corallites. Old visceral chambers very shallow, transversely elongate.

Obs.—This form is remarkable for its very regularly horizontal and exceedingly close tabulæ, reducing the old visceral chambers to the shallowest capacity. The mural pores, as in *F. gotlandica*, are in two alternate series on each face of a corallite, and devoid of raised margins, but the diameter of the corallites is between that of the two varieties of *F. basaltica*. The spiniform septa are short, and numerous in a cycle; they are best seen on weathered surfaces.

Prof. Ferdinand Roemer figured a species of *Favosites* from the Upper Silurian of Tennessee* with equally close tabulæ, that he referred to *F. gotlandica*, and Prof. James Hall another from the Hamilton series, distinguished as *F. argus*.†

I have other forms closely resembling this species, from the Upper Silurian of Hatton's Corner, and Silverdale, near Yass.

The visceral chambers and other cavities are filled almost wholly with crystalline calcite, with here and there a few specs of quartz.

Loc. and Horizon.—Beedle's Freehold, near Moonbi, north-east of Tamworth (*T. Beedle.*)—Moonbi Limestone.

Favosites, *sp. ind.*

(Pl. XVII, Figs. 2 and 3.)

Obs.—A single specimen of a *Favosites*, one portion remaining as a weathered vortical section, forcibly reminds us of *F. Forbesi*, Ed. and H.

The corallum is strongly clavate, one of the forms assumed by *F. Forbesi* when young, with a tapering peduncular base, and an expanded upper portion, the corallites opening on all sides of the entire colony. The corallites are both large and small, the latter either surrounding the former, or dovetailed between them. The weathered state of the specimen is opposed to accurate measurements, but the

* Sil. Fauna W. Tennessee, 1860, t. 2, f. 9b.
† Ill. Dev. Foss.: Corals Up. Helderberg and Hamilton Groups, 1876, t. 18, f. 5.

larger corallites appear to have a diameter of from two to three millimetres, while that of the smaller is very variable. The mural pores are arranged in from one to two rows on each corallite face, when the latter predominate the rows are alternate; there is no rim-like margin, but on the contrary the pores seem to be sunk in depressions of the wall surface. Septa are represented by irregular cycles of granules. The tabulæ are very imperfectly preserved, but seem to have been complete and horizontal.

Microscopic sections could not be made without wholly destroying the identity of the specimen, and it follows from this that specific determination must remain in abeyance. It may, however, be pointed out that the resemblance of this coral to certain illustrations of *F. Forbesi*, and its var. *occidentalis*, Hall,* is very marked, and also to *F. tuberosa*, Rom.,† a near ally of *F. Forbesi.*

Loc. and Horizon.—Beedle's Freehold, near Moonbi, north-east of Tamworth (*T. Beedle.*)—Moonbi Limestone.

b. Dendroid or branching species.

Favosites Pittmani, *sp. nov.*

(Pls. XVIII, Figs. 1 and 2; XXXIV.)

Sp. Char.—Corallum dendroid, composed of large, free, bifurcating branches, from ten to thirteen millimetres in diameter, never inosculating; distal ends terete. Corallites large, polygonal, when mature tolerably equal in size, with smaller individuals frequently intercalated in the angles of the larger. Calices large, from one to three millimetres in diameter, the average being two millimetres, polygonal, covering the entire free surface of the corallum, bell-mouthed and slightly oblique, the lower margins projecting; edges of the calices sharp and exsert. Walls below the level of the corallites much thickened by secondary deposit. Septa in the form of indistinct sparse spinules, irregularly distributed. Mural pores large, very apparent in the walls of the calices, one or two rows on each angular face, when single in a central vertical row one millimetre apart, when double opposite to one another. Tabulæ very indistinctly preserved, but delicate, and apparently complete, about three in the space of one millimetre.

Obs.—The macroscopic characters of this coral are very distinctly preserved, but from the high state of alteration the microscopic are very indistinctly so.

The calices are close to one another, the thickening of the walls being very much more marked below their level and in the axial region. They are wide, deep, and expanded, becoming somewhat bell-mouthed, with sharp sub-crested margins, but not contracted below to a lumen. There is also a decided, though slight obliquity, the lower margin of each polygonal opening projecting.

* 28th Ann. Rept. N. York State Mus., 1879, t. 4, f. 7, 8. 10.
† Hall, Ill. Dev. Foss.: Corals Up. Helderberg and Hamilton Groups, 1876, t. 6, f. 2 and 3.

The septa appear to be represented by indistinct and irregularly scattered spinules, only apparent in very well-preserved calices, more often than not they seem to be worn off, and the walls are smooth.

The mural pores are very numerous, and here and there they may be seen to have raised margins or rims as in the *F. gotlandica* group of massive *Favosites*. These pores form a very marked feature in the calices, reminding us of similar appearances in certain forms of *Michelinia*, such as *M. grandis*, McCoy,* and *M. convexa*, D'Orb., as figured by Hall.†

In a vertical section prepared for the microscope the thickened walls are quite apparent, consisting of a dense grey unlaminated sclerenchyma, the thickening rapidly increasing from the thin calice peripheries downwards towards the axial region, all trace of the primordial wall being lost, nor is there any thickening at the base of the calices with an aperture or lumen, as in *Pachypora* and *Striatapora*. The old visceral chambers are long and narrow tubes, divided transversely at distant intervals by delicate tabulæ. This section further demonstrates the entire absence of septal granules in the tubes below the polygonal cups. Mural pores are occasionally visible.

The mineral constituents seem to be almost wholly chalcedonic quartz, very finely divided, and a little granular calcite here and there.

Doubt has arisen in my mind as to the selection of a genus to receive this very handsome and striking coral, and I had in MS. referred it to *Pachypora*, Lindström, having, in common with several other writers, quite misunderstood this genus. Now, however, that Dr. Lindström has published‡ a detailed description of *Pachypora*, proposed by him with a very brief description in 1873,§ the error promulgated by myself and others in our conception of it becomes apparent and is excusable. Dr. Lindström considers that of the species included in *Pachypora* since 1873, only one, exclusive of his type, is correctly so placed.

In the present coral there is no trace of the concentric sclerenchymatous laminæ around the calice apertures—no, strictly speaking, alveolitoid calices, no lumen or pseud-operculum, no defined septal spines or radial channels, as figured by Lindström, and it is therefore impossible to include it in *Pachypora*.

I also had under consideration *Striatopora*, Hall, to the calices of which those of the present species exhibit considerable resemblance, but here again the absence of radial striæ on the calice floors entirely removes *F.? Pittmani* from the proximity of such species as *Striatopora linneana*, Bill., or *S. flexuosa*, Hall, two of the best marked species of the genus, although Nicholson states‖ that this character is not

* Brit. Pal. Foss., Fas. 1, 1851, t. 3c, f. 1.
† Ill. Dev. Foss.: Corals Up. Helderberg and Hamilton Groups, 1876, t. 15A, f. 8.
‡ Bihang. Vet.-Akad. Förhandl. Stockholm, 1896, Afd. 4, No. 7, p. 23.
§ Öfversigt Vet.-Akad. Forhandl. Stockholm, 1873, XXI, No. 4, p. 14.
‖ Tab. Corals Pal. Period, 1879, p. 99.

always present in *Striatopora*. A further dissimilarity is evinced by the absence in *F. ? Pittmani* of the circular apertures at the bottom of the cup-shaped calices in the forementioned species of Hall's genus.

Cladopora, Hall, again, was another genus investigated for purposes of comparison, but in the present unsatisfactory state of our knowledge of the forms comprising it, it is almost impossible to say what is and what is not *Cladopora*. To Hall's type, *C. seriata*;* although a small coral, there is certainly some resemblance, but less so to his other species, and only in a slight degree to many of those figured by Rominger and Davis.

Last of all, a few words about *Alveolites*. This genus was described by Messrs. Milne Edwards and Haime as possessing oblique calices "presenting interiorly a longitudinal protuberance, which is opposed to two other smaller protuberances. These eminences appear to represent the primary septa; and no other trace of the septal apparatus can be detected."† And in another work they say ‡—"The elongated teeth or vertical projections which we see in the interior of the visceral chambers of the corallites form the most peculiar character of *Alveolites*." In reviewing *Alveolites*, Prof. Alleyne Nicholson and the Writer remarked §—"We have satisfied ourselves that no other character can be brought forward which is sufficiently important to elevate *Alveolites* to the rank of a genus distinct from *Favosites*."

No trace of this septal apparatus has presented itself in *F.? Pittmani*, and in consequence of this, as well as the abundance of the mural pores, I think *Alveolites* may be dismissed from consideration.

Under these circumstances I provisionally place this coral in *Favosites*, calling attention to its general resemblance to *F. arbuscula*, Hall,‖ and *F. cavernosa*, Davis.¶

Named in honour of Mr. E. F. Pittman, A.R.S.M., Government Geologist.

Loc. and Horizon.—Beedle's Freehold, near Moonbi, north-east of Tamworth (*T. Beedle.*)—Moonbi Limestone.

Favosites ? Crummeri, *sp. nov.*

(Pls. XIX, Figs. 5 and 6; XXXV.)

Sp. Char.—Corallum dendroid, consisting of stout, bifurcating branches from ten to fifteen millimetres in diameter; inosculation not observed. Corallites sub-polygonal in the peripheral and axial regions, moderately large, and fairly equal in size throughout. Walls greatly thickened in the peripheral region, in

* Pal. N. York, 1852, II, p. 137, t. 38, f. 1 *a.-m.*
† Polyp. Foss. Terr. Pal., 1851, p. 254.
‡ Hist. Nat. Coral., 1860, III, p. 264.
§ Proc. Linn. Soc. (Zool.), 1878, XIII, p. 360.
‖ Ill. Dev. Fossils: Corals Up. Helderberg and Hamilton Groups, 1876, t. 36.
¶ Kentucky Foss. Corals, 1885, t. 33.

the axial region less thickened; primordial walls sometimes visible in the axial region, revealing the more or less polygonal outline of the corallites. Calices open, rather bell-mouthed, very slightly oblique, the lower margin projecting, decreasing in size downwards; diameter at the peripheries from one to one and a half millimetres, the average being one, occasionally reaching as much as two. Septa not observed. Mural pores few and much scattered.

Obs.—In the axial region the corallites are long, and through the thickening of the walls by secondary deposit, the visceral chambers are reduced to mere cylindrical tubes, in which it is very rare to see tabulæ. On the corallites curving to open in the peripheral region, the thickening is much increased, and it is maintained to the actual edge of the calices. The sclerenchyma of this portion is dense, and so far as I can detect non-perforate; nor have I been fortunate enough to observe septa.

This apparent paucity of mural pores seems to point towards *Alveolites*, but in the absence of the characteristic septal ridges of the latter, a reference of the present coral to it cannot be entertained.

Favosites ? Crummeri is allied to a coral called by Prof. Alleyne Nicholson and the Writer, *Pachypora meridionalis*,* but which, in the light of Dr. Lindström's later description of *Pachypora*, probably ceases to be a species of that genus, and requires further elucidation. It, however, possesses thickened walls in the peripheral region composed of laminated sclerenchyma.

The present species appears to be intermediate between *Favosites ? (Pachypora) meridionalis* and *F.? Pittmani*, the corallites much larger than in the former, where they are not more than a third of a line in diameter, but smaller than in the latter. In external appearance *F.? Crummeri* is wonderfully like some of the branching and inosculating forms of *Cladopora*, Hall, as figured by Rominger. Did we but know more of the characters by which the heterogeneous assemblage of species, known as *Cladopora*, could be reduced within reasonable limits, it is possible that the present coral would find a resting-place amongst such species as *Cladopora cryptodens*, Billings,† and *C. robusta*, Rom.‡ If a true *Favosites*, an alliance should be looked for in the vicinity of *F. cervicornis*, Blainv., and *F. baculus*, Davis.§

The corallum is entirely composed of granular calcite, with here and there blebs of chalcedonic quartz.

Loc. and Horizon.—Moore Creek, near Tamworth (*T. W. E. David.*)—Moore Creek Limestone.

* Ann. Mag. Nat. Hist., 1879, IV, (5), p. 280, t. 14, f. 4 *a–c*.
† Rominger, Report Gool. Survey Michigan. Lr. Peninsula, 1873-76, III, Pt. 2, t. 20, f. 1 and 2.
‡ *Ibid*, t. 22, f. 1 and 2.
§ Kentucky Fossil Corals, 1885, t. 21, f. 1-4.

GENUS ALVEOLITES, *Lamarck*, 1801.

(Syst. Anim, sans Vertéb., p. 375.)

Alveolites ?, *sp. ind.*

(Pl. XVII, Figs. 4 and 5.)

Obs.—An agglomerated mass of small cylindrical bodies, lying at all angles to one another, with a rough, and apparently vermiculate surface, suggested *Amphipora*, a genus of Stromatoporoidea. Microscopic sections, however, notwithstanding the highly altered and silicified condition of the whole mass, at once dispelled this idea, and lead to the belief that these fragments may be broken up dendroid corallums of an *Alveolites*, after the type of *A. repens*, Linn. Beyond the fact that it is not an *Amphipora* the sections yield little or no definite information.

The fragments consist of short stems, with a diameter of one to two millimetres, without any direct evidence of branching or inosculation. The exterior is roughened by a series of cell apertures, that open on all sides of the stems, some apparently circular, others elongate, and again many vermiculate, a variety of appearance no doubt due to the highly altered condition of the colonies.

The mineral condition seems to be a mass of chalcedonic quartz and granular carbonate of lime.

Loc. and Horizon.—Near Tamworth (*D. A. Porter*).

GENUS HELIOLITES, *Dana*, 1846.

(Wilkes' U.S. Explor. Exped., Zoophytes, p. 541.)

Heliolites porosa, *Goldfuss.*

(Pls. XIX, Figs. 3 and 4; XXV, Figs. 1 and 2.)

Astræa porosa, Goldf., Petrefacta Germaniæ, 1826, I, p. 61, t. 21, f. 7.

Heliolites porosa, Edw. and H., Polyp. Foss. Terr. Pal., 1851, p. 218.

" " De Koninck, Foss. Pal. Nouv.-Galles du Sud, Pt. 1., 1876, p. 81.

" " Nicholson and Etheridge, Junr., Ann. and Mag. Nat. Hist., 1879, IV (5), p. 223.

Obs.—The specimens of this world-wide species in the Moore Creek Limestone are in the form of large masses, but the precise shape of the colonies is unknown to me, for I have by no means seen anything approaching complete examples.

The circular autopores maintain a very uniform diameter of from one to one and a half millimetres, and are fairly equally developed in the same specimen, the distance apart varying from one to three millimetres; they are circular, with either plain margins, or the latter are scalloped by the inward projection of twelve well-marked septa, which are straight, and about one-third the diameter of the

autopores in length. The tabulæ are very regular, generally horizontal, and vary a good deal in their distance apart, but when any degree of constancy is exhibited from three-quarters to one millimetre apart.

The siphonopores are very variable in size and form, but always polygonal, one quarter to one third of a millimetre in diameter, and vary from two to six in number between contiguous autopores, but the more common number is three or four. There is not that well-marked circlet of large and similarly shaped siphonopores around each autopore that is sometimes seen in examples of this species from other localities, and in other species. The tabulæ are very regularly spaced about three in the space of one millimetre, horizontal, and either opposite or sub-opposite in contiguous tubes.

In the Moore Creek Limestone *H. porosa* weathers into very beautiful specimens, leaving the whole of the tissues exposed, so that the structure can be studied almost as well in this condition as in microscopic sections.

It is not my intention to enter deeply into the structure of this species at the present time, as I have in preparation an account of the whole of the N. S. Wales and Queensland *Heliolites*, when the affinities of the various species will be more appropriately discussed.

The mineral structure of these specimens assumes three forms—(1) the corallites are entirely filled with crystalline calcite; (2) the corallites have crystalline calcite linings and crystalline quartz centres, both of variable diameter, sometimes the one mineral predominating, sometimes the other; (3) the corallites are entirely filled with crystalline quarts, especially the autopores. The whole of the tissues are dense.

Loc. and Horizon.—Parish of Woolomol, near Tamworth (*T. W. E. David.*) —Woolomol Limestone; Moore Creek, near Tamworth (*T. W. E. David.*)—Moore Creek Limestone.

GENUS SYRINGOPORA, *Goldfuss*, 1826.

(Petrefacta Germaniæ, 1826, I, p. 75.)

Syringopora auloporoides, *De Koninck.*

(Pl. XXVIII, Figs. 1 and 2.)

Syringopora auloporoides, De Kon., Foss. Pal. Nouv.-Galles du Sud., Pt. 1, 1876, p. 76, t. 3, f. 1.

Sp. Char.—Corallum cladochonoid in appearance, straggling, but forming large masses. Corallites circular, loosely aggregated, irregularly placed with regard to one another, distributed at all angles throughout the matrix, and variable in diameter; seldom sufficiently regular to be united by connecting processes, but the tubes frequently and irregularly dichotomous, the angle of dichotomy being

variable, and repeatedly giving off short and bud-like calices on all sides, that frequently alternate with one another; diameter one millimetre. Walls thick, encased in an epitheca. Septa not discernible. Tabulæ infundibuliform, but not acutely so.

Obs.—A species of very straggling growth, the corallites projecting through the matrix surface in all directions, and at various angles, imparting to the corallum a very disjointed appearance. De Koninck says that the corallum "ordinarily commences by being somewhat creeping, and on attaining a length of five or six millimetres, gives rise to buds, which are elongated and elevated more or less vertically, but their development is never considerable and does not exceed five centimetres."

Only one instance has come under my notice of any attempt to form parallel tubes, united by connecting processes, all the other examples being of a cladochonoid or auloporoid nature, forming a confusedly jumbled mass of bifurcating and sometimes geniculate corallites. This varied direction of the corallites, and the highly altered nature of the corallum, has rendered it very difficult to obtain satisfactory microscopic sections. In a horizontal section all that is visible are the thick walls, and the infundibuliform tabulæ, in some instances strictly concentric within one another, and conforming to the outline of the tubes; in others very irregular. It is by the merest chance that a true vertical section can be obtained, the sections being at all kinds of angles in consequence of the irregular growth of the corallum. The tabulæ are by no means numerous, and not acutely infundibuliform. One fact appears tolerably certain, however, there are no septa.

The bud-like calices closely resemble those of *Cladochonus*, or even those of *Aulopora repens*, Linn., the resemblance to the former being intensified by the absence of septa; in fact, the general appearance of the coral is far more cladochonoid than auloporoid, but the infundibuliform tabulæ at once distinguish *S. auloporoides*, those of *Aulopora* and its allies being transverse and complete, whilst in *Cladochonus* the presence or absence of these organs is still an open question.

I quite fail to appreciate the comparison drawn by Prof. De Koninck between *S. auloporoides* and *S. cæspitosa*, Goldf. To my eye it is much more like *S. tenella*, Rom.,* and even *Aulopora conglomerata*, Goldf.,† in its general features. The species may be very readily recognised in the mass by the small size of the corallites, and the irregularity of their growth.

The corallites are filled with crystalline calcite, and occasional blebs of chalcedonic quartz have impinged on the walls.

* Report Geol. Survey Michigan. Lr. Peninsula, 1873-76, III, Pt. 2, p. 81, t. 30, f. 4 (r. hand low. fig.)
† Petrefacta Germaniæ, 1826, I, t. 29, f. 4, 4a.

Loc. and Horizon.—Parish of Woolomol, near Tamworth (*T. W. E. David.*)—Woolomol Limestone; Moore Creek, near Tamworth (*D. A. Porter.*)—Moore Creek Limestone. [In all probability the present specimens are from De Koninck's type locality, which he wrote "Moara Creek," to the north of Tamworth. An illegible label would easily account for the unconscious error.]

Syringopora Porteri, *sp. nov.*

(Pls. XVIII, Fig. 3; XXXI, Figs. 1 and 2.)

Sp. Char.—Corallum straggling, forming a loosely aggregated mass, somewhat auloporoid in appearance. Corallites circular, apparently of no great length, sub-parallel, or curved and distorted in growth, one and a half to two millimetres in diameter. Walls immensely thickened, enclosing visceral chambers reduced to mere narrow undivided tubes. Calices bud-like, expanding, springing from the corallites at irregular intervals, either singly, or alternate on opposite sides of the parent corallite, or two or more developed around the latter at the same level. Septa numerous, long, but small in diameter, visible with an ordinary pocket lense. Tabulæ scanty, but when present infundibuliform.

Obs.—It was exceedingly interesting to meet in the same deposit with two species of *Syringopora*, both possessing auloporoid or cladochonoid characters in the form and disposition of the calices. I at first took this coral to be only a large variety of *S. auloporoides*, but the microscopic details are so very different that I do not feel justified in uniting them. In the present species the walls are inordinately thick, and although they are substantial in *S. auloporoides*, their diameter is by no means equal to that of *S. Porteri*. Septa are likewise plentifully developed in the latter, but are not present in the former. Similarly, tabulæ are a marked feature in *S. auloporoides*, but very scantily distributed in *S. Porteri*. The difference in the diameter of the corallites is also striking.

The mode of growth in some respects resembles that of *Cladochonus*, but the existence of spiniform septa and infundibuliform tabulæ at once distinguish *S. Porteri*. I would tentatively call attention also to a general resemblance to *Aulocystis*, Schlüter,* but until more is definitely known of the habit of growth of the present species it is preferable to leave it where placed.

The coralites are usually filled with granular calcite, with here and there an edging around the tissues of chalcedonic quartz; in places the wall tissue is replaced by this mineral.

Loc. and Horizon.—Moore Creek, near Tamworth (*D. A. Porter.*)—Moore Creek Limestone.

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* Abhandl. Geol. Specialkarte preuss. Thüring. Staaten, 1889, VIII, Heft 4, p. 162.

Syringopora novæ-cambrensis, *sp. nov.*

(Pls. XVIII, Figs. 4 and 5; XXIX, Fig. 1; XXXIII, Figs. 1 and 2.)

Sp. Char.—Corallum forming moderately large masses. Corallites cylindrical, long, straight, oval or round, with an average diameter of two millimetres, very evenly developed and equidistant. Connecting processes simple hollow tubes uniting the corallites at very regular intervals, and practically on the same level throughout the corallum, from two to three millimetres apart, at times filled with vesicular endothecal tissue. Walls thick. Septa present, but very irregularly developed. Tabulæ numerous, slightly concave to definitely infundibuliform, in a few instances horizontal; when infundibuliform the axial tube is well developed, and surrounded by copious enveloping tabulæ.

Obs.—A very regularly grown species, partaking in a marked degree of characters that one is accustomed to associate with Carboniferous species.

The walls are thick, and composed of cloudy and here and there laminated sclerenchyma. The septa are very irregular in their occurrence, and always few in a cycle, but when present short and spiniform, and conspicuously darker than the surrounding tissues. *S. novæ-cambrensis* possesses the undoubtedly peculiar character of exhibiting both infundibuliform, oblique, slightly concave, or even horizontal tabulæ all in the same corallite. The corallites vary in diameter from one and a half to two and a quarter millimetres, but the average is two; the greatest distance observed between superimposed connecting processes being five millimetres. The wall is often a quarter of a millimetre thick, and the corallites average two millimetres apart.

The regularity of the connecting processes when seen on a vertical fractured surface imparts to the corallum a strong resemblance to a *Fenestella*, with large interstices and an absence of pores. In this respect *S. novæ-cambrensis* approaches *S. verticillata*, Goldf.* In the parallelism of its corallites, an affinity can be traced to the Devonian *S. cæspitosa*, Goldf.,† but no instance of bifurcation has been observed, and to many Carboniferous species, such as *S. reticulata*, Goldf.,‡ and *S. distans*, Fischer.§ Other Devonian forms with an equal resemblance are *S. Maclurei*, Billings, and *S. perelegans*, Billings, both as figured by Rominger.

The mineral condition is that of crystalline calcite, with a few scattered specks of chalcedonic quartz.

Loc. and Horizon.—Thirty miles north-west of Tamworth (*D. A. Porter.*)—[? Carboniferous.]

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* Petrefacta Germaniæ, 1826, I, t. 25, f. 6a.

† *Ibid*, t 25, f. 9a.

‡ *Ibid*, t. 25, f. 8.

§ Thomson, Corals Carb. System Scotland, 1883, p. 35.

GENUS LITOPHYLLUM,* *gen. nov.*

Gen. Char.—Corallum of very simple structure, massive, possibly also dendroid or encrusting. Corallites monomorphic, erect, polygonal, firmly amalgamated; neither monticules, nor acanthopores. Walls imperforate. Septa none, nor are the visceral chambers partially divided by longitudinal imperfect lamellæ. Tabulæ complete and very regular, but not continued across contiguous corallites so as to give rise to horizontal continuous layers. Increase by intermural gemmation.

Litophyllum Konincki, *Eth. fil. and Foord.*

(Pls. XVIII, Fig. 7; XXXVI; XXXVII, Fig. 1.)

Amplexopora Konincki, Eth. fil. and Foord, Ann. Mag. Nat. Hist., 1884, XIV (5), p. 178, t. 6, f. 3–3*c*.

Amplexopora Konincki, Eth. fil., Geol. and Pal. Q'Land, &c., 1892, p. 55, t. 2, f. 7–9*a*.

Sp. Char.—Corallum massive, large, different colonies growing on, or attached to one another. Corallites subpolygonal, straight, variable in size, but always minute, from three to four in the space of one millimetre, the angles rounded. Walls somewhat thickened, when the outline becomes less polygonal. Tabulæ complete, remarkably regular, thin, horizontal, distant, opposite or sub-opposite in contiguous tubes, four or five in the space of one millimetre.

Obs.—This coral, which I have selected as a type of a suggested new genus, is remarkable for the simplicity of its structure—no septa, no subdivision by longitudinal lamellæ, no dissepimental or other vesicular tissue, no columella, no mural pores, no obliquity of calice mouths, but simple tubes opening on the surface at right angles to their longest diameters, and subdivided by a plentitude of tabulæ—and as I hope to show later on, differing in these particulars from others that may be regarded as its allies.

Examples from the Tamworth District, collected by Prof. T. W. E. David, exhibit a remarkable similarity in structure, to those from the type locality near Townsville, not only micro- but also macroscopically, so much so indeed that it would be difficult to separate them, were it not for the possession of authenticated examples. As a New South Wales form this was first made known to me through specimens collected by Mr. William Anderson, late of the New South Wales Geological Survey.

Spiniform corallites were figured by Mr. A. H. Foord and myself from the original specimens, and in consequence of their otherwise simple structure the latter were referred to the genus *Amplexopora*, Ulrich. I am now, however,

* λιτός, plain, simple, unadorned.

strongly of opinion, that such do not exist, and we must have been misled by deceptive appearances. There are certainly no spiniform corallites in the Tamworth specimens, and I have re-examined examples from the type locality, without again observing them. The only difference between the Tamworth and Reid's Gap corals, that I can detect, is, that in the former the polygonal outline of the corallites is to a large extent lost through thickening. Mr. Foord and myself remarked that we were "at first under the impression that it might be a *Chætetes*," and the first impression was, I believe, much nearer to the truth than the subsequent determination. I suspect the misconception arose from a peculiar discolouration of the walls sometimes visible at the angles of junction of the corallites, and occasionally also in the walls between these points. The evidence afforded by vertical sections at once proves the absence of any structure approaching that of an acanthopore. This being the case, the question arises to what genus of Tabulata, this coral of such remarkably simple structure, should be referred.

The absence of mural pores at once removes *Amplexopora Konincki* from all genera of the Favositidæ; the want of infundibuliform tabulæ eliminates it from the Syringoporidæ, and the Thecidæ need not be referred to; the monomorphic corallites forbid any reference to the Heliolitidæ; the massive form of the corallum, to say nothing of other features, removes it from the Halysitidæ and Auloporidæ; the absence of pseudo-septa, in the form of longitudinal inflections of the corallite walls, renders a reference to the Tetradiidæ hardly necessary, whilst the entire absence of mesopores, acanthopores, and monticules places it quite outside the Monticuliporidæ, leaving for consideration three genera, viz.—*Chætetes*, *Beaumontia*, and *Dania*, the two latter being very imperfectly known.

The simple structure seen in *Litophyllum* is repeated in *Chætetes*, viz., the close, erect, more or less prismatic, completely amalgamated, monomorphic corallites, with non-oblique calices; absence of mural pores and septa, and the presence of complete, horizontal tabulæ. On the other hand, there is not a single instance of the inflection of the walls, first pointed out in *Chætetes* by Lonsdale as an indication of fission, and usually called the "septal tooth," for in this instance the colony augments by intermural gemmation. Under these circumstances the present coral cannot, with propriety, be referred to *Chætetes*.

In *Beaumontia* there are neither septa nor mural pores, at least, so far as I know, these organs have not been shown to exist in *Beaumontia*, although the presence of mural pores has been suspected,* and the genus placed by Lindström† in the Favositidæ, but on what evidence I do not know. The tabulæ are irregular, or vesicular,‡ and the walls do not appear to be amalgamated in the same

* Nicholson, Tab. Corals Pal. Period, 1879, p. 329.

† Ann. Mag. Nat. Hist., 1876, XVIII (4), p. 16.

‡ Edwards and Haime, Brit. Foss. Corals, Pt. 3, 1852, t. 45, f. 1.

sense as in *Chætetes* and *Litophyllum*. In *Beaumontia* the corallites separate on fracture and display the exteriors, but in both the genera named fracture invariably lays open the interiors of the corallites.

Some doubt* has been assigned to the characters given by Edwards and Haime of their genus *Dania*, but if the observations of these eminent Naturalists are correct, *Dania* fulfills all the requirements necessary for the inclusion in it of the present coral, except in one important particular. Edwards and Haime described† *Dania* as—"Corallum massive, composed of prismatic corallites, which are intimately united by their well-developed walls. Tabulæ completely horizontal, and continued across contiguous corallites in such a manner as to give rise to continuous lamellæ, which divide the entire mass into a series of superimposed strata. Calices, subpolygonal. No traces of septa." To this Prof. Alleyne Nicholson adds‡—"It is clear from their description, and still more from their figures, that *Dania Huronica* is a Chætetoid or Monticuliporoid Coral; and it is also clear that the single character emphasised by Milne-Edwards and Haime—namely, the presence of tabulæ placed at corresponding levels in contiguous tubes—is not of itself sufficient for generic characterisation." It seems to me that Prof. Nicholson, in these and his succeeding remarks, has generalised too hastily, for if *Dania huronica* does not possess the wall inflection known as the "septal tooth," and if the tabulæ fracture lines are constant throughout several species, I fail to see how it can be properly referred to *Chætetes*, for in the latter these lines of separation are not only inconstant in the same species, but absent in some, just as in *Stenopora* also, and entirely absent in *Litophyllum*.

It will be observed that *Dania* and *Litophyllum* both agree in the absence of septa and mural pores, and it might be argued that it would have been better to refer the Australian coral to *Dania* rather than propose a new genus for its reception, but from the uncertain position occupied by the former, I have preferred to adopt the course here taken. Again in establishing this genus I do not forget that the "septal tooth" in *Chætetes* is sometimes "barely perceptible, or even wholly absent."§ It is, however, very rare to meet with a true *Chætetes* in which this longitudinal inflection of the corallite wall cannot be perceived in some of the tubes, but in all the examples of *Litophyllum Konincki* that I have examined, I have failed to detect a single instance of its presence. I can only conclude from this that the reproduction in the latter was not fissiparous. Even in *Chætetes* proper the walls are more or less thickened, the primordial wall becoming lost. This is shown in figures of *C. septosus*, Flem., sp., and *C. radians*, Fischer, published by Prof. Alleyne Nicholson and myself,‖ but there is not that rounding-off of the corallite angles met with in *L. Konincki*, the polygonal outline in the latter to a very great extent becoming lost.

* Nicholson, Tab. Corals Pal. Period, 1879, p. 328.
† Polyp. Foss. Terr. Pal., 1851, p. 275.
‡ *Loc. cit.*, p. 328.
§ Nicholson and Etheridge, Junr., Proc. Linn. Soc. (Zool.), 1878, XIII, p. 364.
‖ Proc. Linn. Soc. (Zool.), 1878, XIII, t. 19, f. 3 and 9.

It is not impossible that *Chætetes hyperboreus*, N. and E.,* may fall into *Litophyllum*, for no "trace of a septal apparatus, or of septal teeth" was observed in its structure. An investigation of *C. tenuis*, Hall,† is also advisable.

In examples from the first of the localities mentioned below the corallites are generally filled with crystalline quartz, with here and there a lining of crystalline calcite. In those from the second locality the infilling is entirely crystalline calcite.

Loc. and Horizon.—Manilla Road, fifteen miles north of Tamworth (*W. Anderson.*); Moore Creek, near Tamworth (*T. W. E. David.*)—Moore Creek Limestone.

III.—*Summary.*

The corals described in previous pages group themselves into three well-marked horizons—

1. Moore Creek Limestone, Moore Creek, near Tamworth.
2. Woolomol Limestone, Parish of Woolomol, near Tamworth.
3. Moonbi Limestone, Beedle's Freehold, near Moonbi.

The assemblage of species under Nos. 1 and 2 indicate that the limestones are nearly related, belong to the same series of rocks, and are, taking into consideration the absence of other distinctive fossils, in all probability homotaxial with the Middle Devonian of Europe and America. The species occurring at these two localities are as follows:—

1. Moore Creek Limestone.

Diphyphyllum robustum, *Eth. fil.*
Sanidophyllum Davidis, *Eth. fil.*
Spongophyllum giganteum, *Eth. fil.*
Actinocystis ? cornu-bovis, *Eth. fil.*
Microplasma parallelum, *Eth. fil.*
Favosites gotlandica, *Lamk.*
,, ? Crummeri, *Eth. fil.*
Heliolites porosa, *Goldf.*
Syringopora auloporoides, *De Kon.*
,, Porteri, *Eth. fil.*
Litophyllum Konincki, *Eth. fil. and Foord.*

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* *Loc. cit.*, p. 367, t. 19, f. 11, 12, t. 20, f. 13, 14.
† Ill Dev. Fossils: Corals Up. Helderberg and Hamilton Groups, 1876, t. 37, f. 6–10.

2. Woolomol Limestone.

Actinocystis ? cornu-bovis, *Eth. fil.*
Favosites gotlandica, *Lamk.*
" basaltica, *Goldf.*, var. salebrosa, *Eth. fil.*
? " squamulifera, *Eth. fil.*
Heliolites porosa, *Goldf.*
Syringopora auloporoides, *De Kon.*

With regard to the third locality, little or nothing is known about its stratigraphical position, but I am inclined to believe that it will be found to be somewhat older than the Woolomol and Moore Creek Limestones. The corals are:—

Favosites gotlandica, *Lamk.*, var. moonbiensis, *Eth. fil.*
" multitabulata, *Eth. fil.*
" (c.f. F. Forbesi, *Ed. and H.*)
" ? Pittmani, *Eth. fil.*

The bed occurring at the Manilla Road, fifteen miles north of Tamworth, and containing *Litophyllum Konincki*, E. and F., is, almost to a certainty, on the same horizon as Nos. 1 and 2.

The locality referred to as thirty miles north-west of Tamworth need hardly be referred to, as the one species from thence (*Syringopora novæ-cambrensis*, Eth. fil.) does not of itself offer sufficient evidence of age, but as the country to the west and north-west of Tamworth is occupied by Carboniferous rocks, it is probably from some portion of that formation.

I am much indebted to Mr. T. Whitelegge, of the Australian Museum, for preparing the micro-negatives from which the microscopic enlargements of some of the corals have been reproduced.

Supplementary Note.—At p. 157 I referred to *Spongophyllum contorti-septatum*, var. *præcursor*, Weissermel. When the final proof-sheets of this paper were passing through the press, I for the first time made the acquaintance of Dr. G. Lindström's most excellent essay 'On the "Corallia Baltica" of Linnæus.'* No one is more competent to publish a paper on this important subject than the eminent author named, both from his extensive knowledge of Palæozoic Corals, and his unrivalled means of access to all that concerns his great countryman and fellow Naturalist. As a synonym of one of the Baltic corals, *Madrepora stellaris*, Linn.,† Dr. Lindström places *Spongophyllum contortiseptatum*, Dyb., which was referred to *Endophyllum* by Weissermel, who also, as previously stated, established a var. *præcursor*. Finally, Dr. Lindström refers the whole of these to *Ptychophyllum*, as *P. stellaris*, Linn. sp. This wholly depends on the limit that is to be assigned to the genus *Ptychophyllum*, beyond those characters given by its founders, Edwards and Haime. It does not seem to me that Dybowski's species and Weissermel's variety can be placed in *Ptychophyllum* unless the characters of the latter are widely extended, any more than the coral for which I have proposed the name of *Sanidophyllum*.

* Öfver. K. Vet. Akad. Förhandl. Stockholm, 1895, ZII, No. 9, p. 615.
† p. 630.

PLATE XVI.

Sanidophyllum Davidis, *Eth. fil.*

Portion of the weathered surface of a large colony, two-thirds the natural size. Seven or eight lines of corallites may be distinguished, some in section, and others partly in the round, united by the successive, regularly superimposed connecting floors, and the interspaces filled with matrix; Moore Creek.

Frank R. Leggatt, del.

PLATE XVII.

Sanidophyllum Davidis, *Eth. fil.*

Fig. 1. Corallites, seen from above, on weathered surface of limestone. At the lower end of the figure a corallite is visible partially surrounded by a frill, which is either one of the superimposed platforms, or the calicinal margin of an old corallite; Moore Creek.

Favosites, *sp. ind.*

Fig. 2. Pyriform corallum of a species allied to *Favosites Forbesi*, Ed. and H.

Fig. 3. A portion of a corallite, showing septa and mural pores. x 3.

Beedle's Freehold.

Alveolites? *sp. ind.*

Fig. 4. Portion of a mass of small broken stems, or branches, highly altered.

Fig. 5. A fragment, showing traces of calices. x 4.

Near Tamworth.

1

3

2

5

4

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PLATE XVIII.

Favosites? Pittmani, *Eth. fil.*

Fig. 1. Portions of the corallum.

Fig. 2. Calices showing mural pores. x 2.

Beedle's Freehold.

Syringopora Porteri, *Eth. fil.*

Fig. 3. Portion of the corallum ; Moore Creek.

Syringopora novæ-cambrensis, *Eth. fil.*

Fig. 4. Portion of the corallum in transverse section, polished.

Fig. 5. The same in vertical section, fractured.

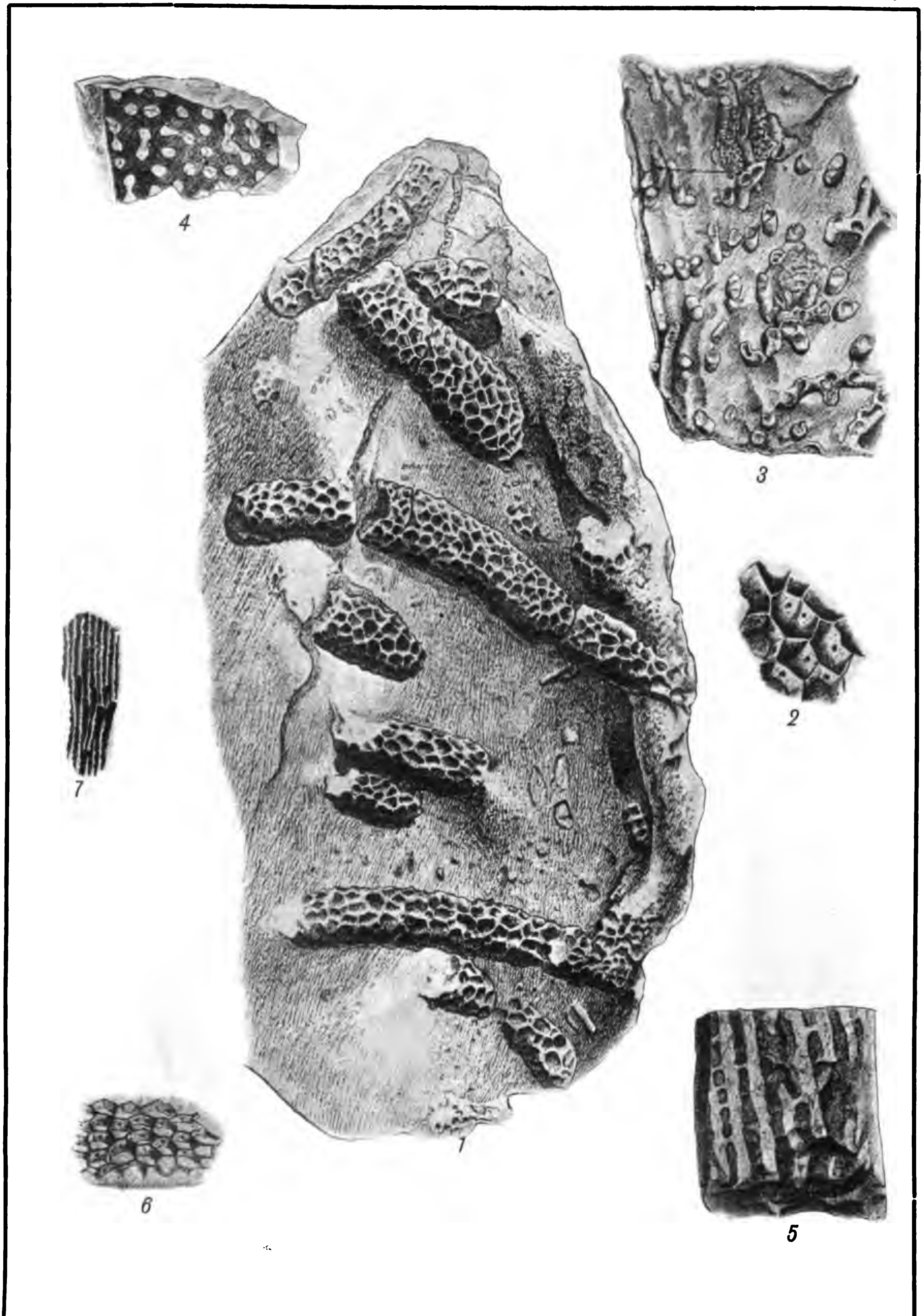
N. W. of Tamworth.

Favosites multitabulata, *Eth. fil.*

Fig. 6. Calices, with mural pores. x 2; Beedle's Freehold.

Litophyllum Konincki, *Eth. fil. and Foord.*

Fig. 7. A few corallites seen in vertical fractured sections. x 2; Moore Creek.



Frank R. Leggatt, del.

PLATE XIX.

Microplasma parallelum, *Eth. fil.*

Fig. 1. Portion of the corallum.

Fig. 2. Three corallites. x 2.

Moore Creek.

Heliolites porosa, *Goldfuss.*

Fig. 3. Portion of a corallum in horizontal view, showing autopores, siphonopores, and tabulæ in the former. x 2.

Fig. 4. Portion of a corallum viewed vertically, showing autopores, siphonopores, and the tabulæ in both. x 2.

Moore Creek.

Favosites ? Crummeri, *Eth. fil.*

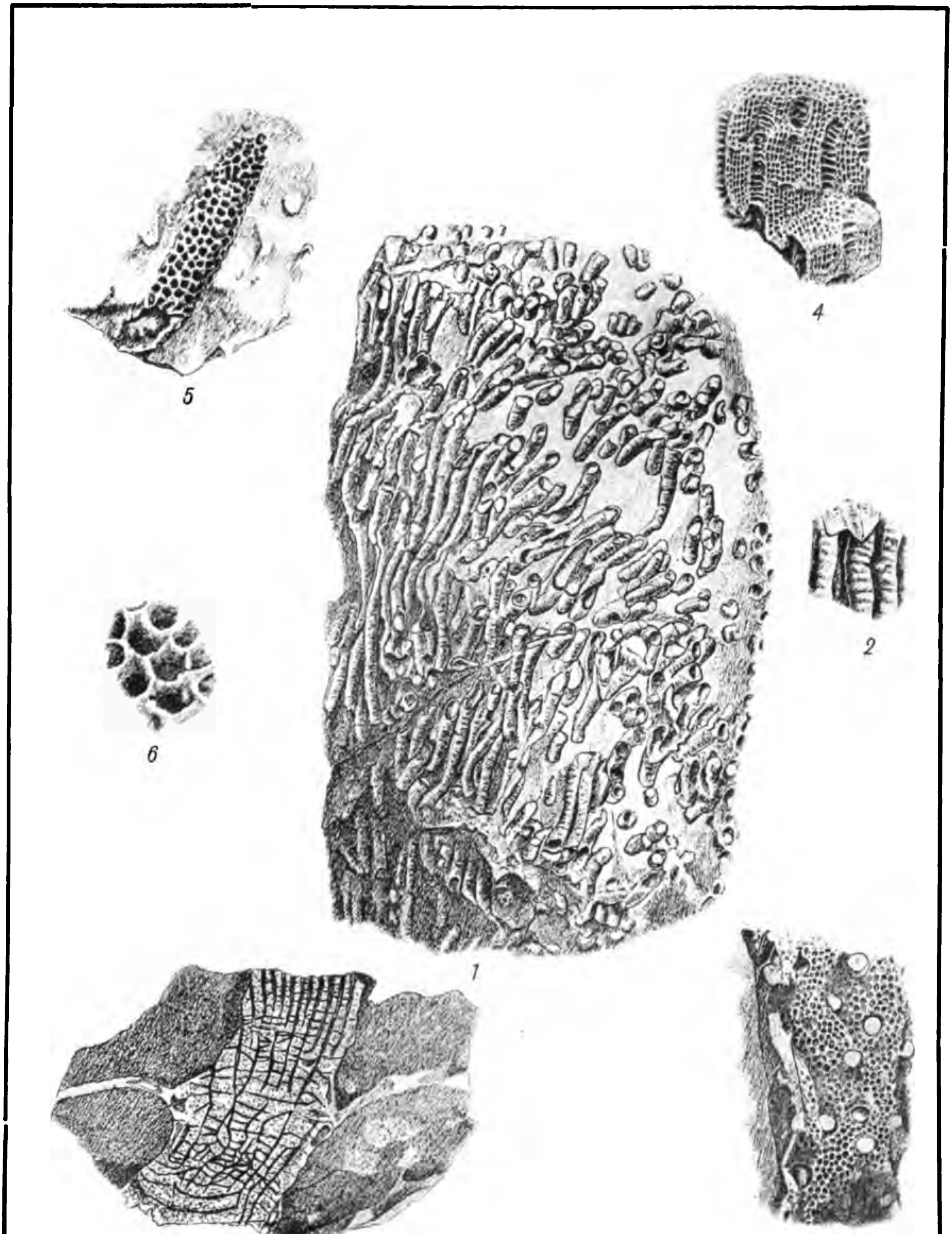
Fig. 5. Portion of a corallum.

Fig. 6. Several calices. x 4.

Moore Creek.

Sanidophyllum Davidis, *Eth. fil.*

Fig. 7. Vertical section of a corallite, prepared for the microscope, showing portions of septa, vesicular tabulæ, and connecting floors. x 2; Moore Creek.



Frank R. Leggatt, del.

PLATE XX.

Spongophyllum giganteum, *Eth. fil.*

Fig. 1. Portion of a large corallum seen from above.

Fig. 2. Horizontal section of corallites prepared for the microscope. x 2.

Fig. 3. A similar section. x 2.

Moore Creek.

Sanidophyllum Davidis, *Eth. fil.*

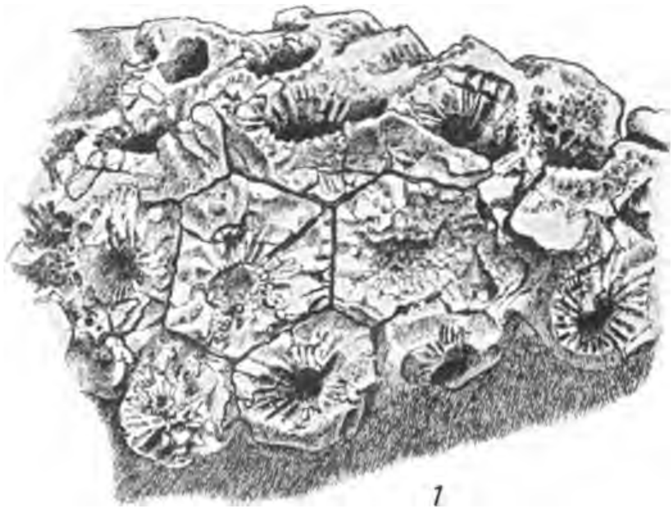
Fig. 4. Vertical section of a corallite prepared for the microscope. x 2.

Fig. 5. Similar horizontal section. x 2.

Moore Creek.

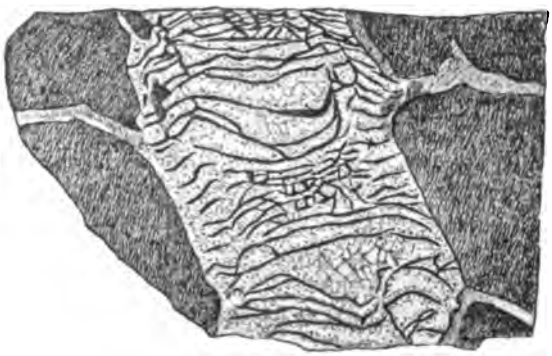
2

3



1

5



4

Frank R. Leggatt, del.

PLATE XXI.

Actinosystis cornu-bovis, *Eth. fil.*

Fig. 1. Transverse section of portion of the corallum, prepared for the microscope, showing the peripheral vesicular area, intermediate septal zone, and central vesicular-tabulate area. x 2.

Fig. 2. Similar view of the weathered upper surface, with like details.

Moore Creek.

Favosites basaltica, *Goldf.*, var. salebrosa, *Eth. fil.*

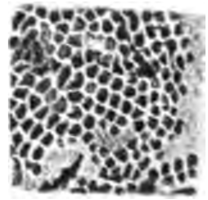
Fig. 3. Portion of the weathered upper surface of the corallum. x 2.

Fig. 4. Portion of the weathered surface, side or vertical view, showing tabulæ. x 2.

Fig. 5. Similar to Fig. 4, but more highly weathered, showing mural pores. x 2.

Woolomol.

4



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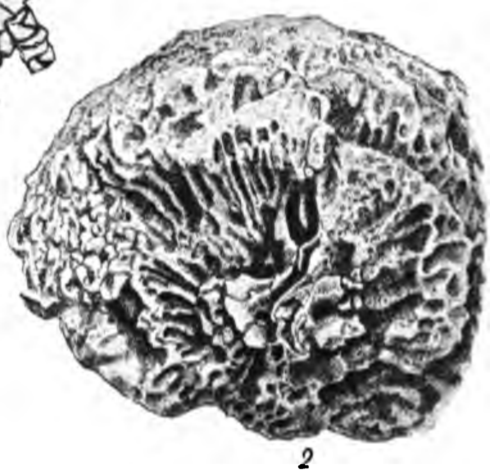

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Frank R. Leggatt, del.

PLATE XXII.

Favosites gotlandica, *Linn.*

Fig. 1. Vertical section prepared for the microscope, showing the somewhat thickened walls, and almost horizontal tabulæ, reproduced from a microphotograph. x 12.

Fig. 2. Similar horizontal section without septa. x 12.

Moore Creek.

1

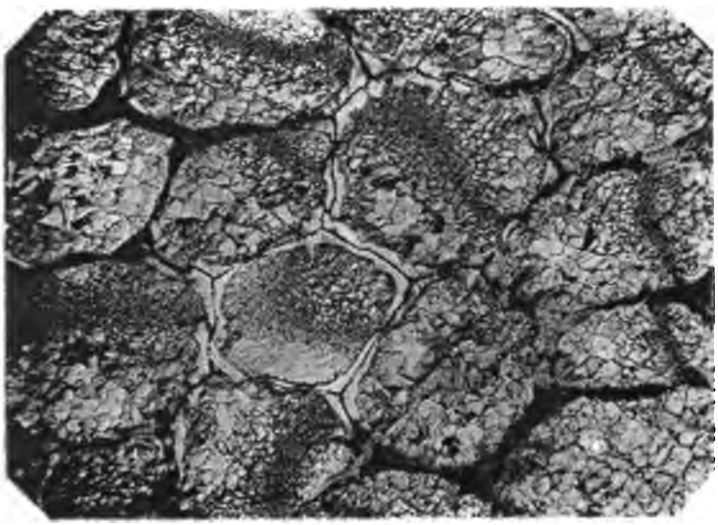

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PLATE XXIII.

Favosites gotlandica, ***Linn.***

Fig. 1. Vertical section prepared for the microscope, showing walls thickened as in Pl. XXII, Fig. 1, and similar, almost horizontal tabulæ. x 12.

Fig. 2. Similar horizontal section, showing septa. x 12.

Woolomol.

1

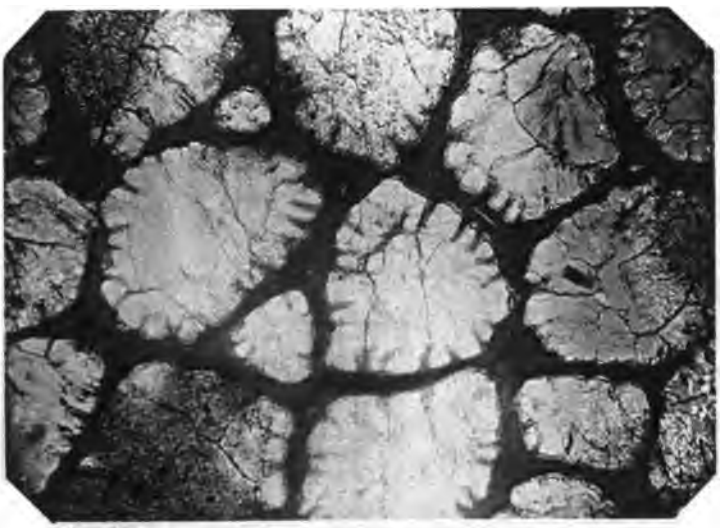

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PLATE XXIV.

Favosites basaltica, *Goldf.*, var. moonbiensis, *Eth. fil.*

Fig. 1. Vertical section prepared for the microscope, showing close, more or less horizontal tabulæ. x 12.

Fig. 2. Similar horizontal section. At the angles of each corallite are light spots resembling some conditions of " spiniform corallites." x 12.

Beedle's Freehold.

1

2

PLATE XXV.

Heliolites porosa, *Goldf.*

Fig. 1. Vertical section of part of a corallum, prepared for the microscope, showing autopores and siphonopores. x 12.

Fig. 2. Similar horizontal section, two of the autopores with septa and three without. x 12.

Woolomol.

1

2

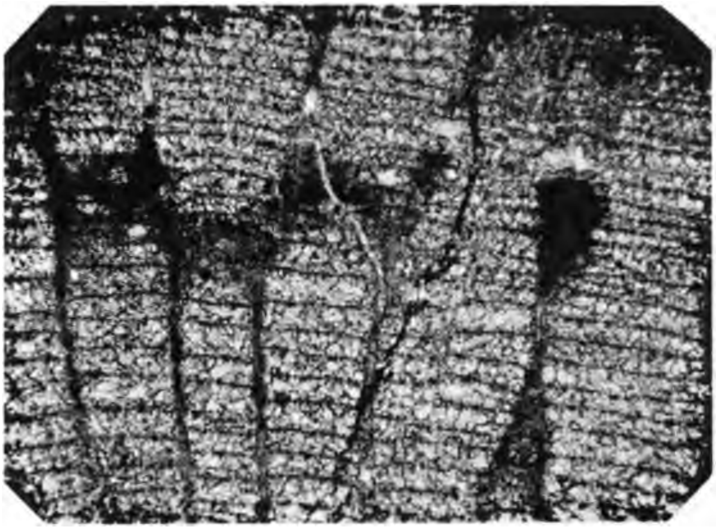
PLATE XXVI.

Favosites multitabulata, *Eth. fil.*

Fig. 1. Vertical section of part of a corallum, prepared for the microscope, showing the remarkably close tabulæ, and the mural pores in two alternate series. x 12.

Fig. 2. Similar horizontal section. The mural pores are here and there seen cutting the corallite walls. x 12.

Beedle's Freehold.



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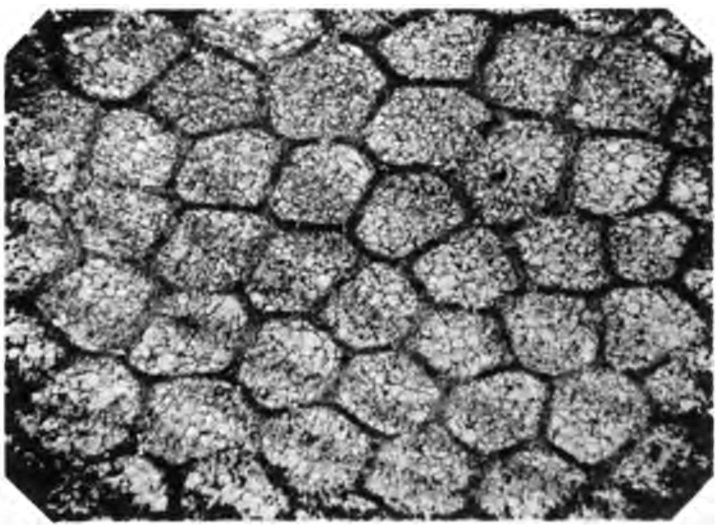

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PLATE XXVII.

Favosites basaltica, *Goldf.*, var. salebrosa, *Eth. fil.*

Fig. 1. Vertical section, prepared for the microscope. x 12.

Fig. 2. Similar horizontal section, the corallites with thickened walls. x 12.

Woolomol.

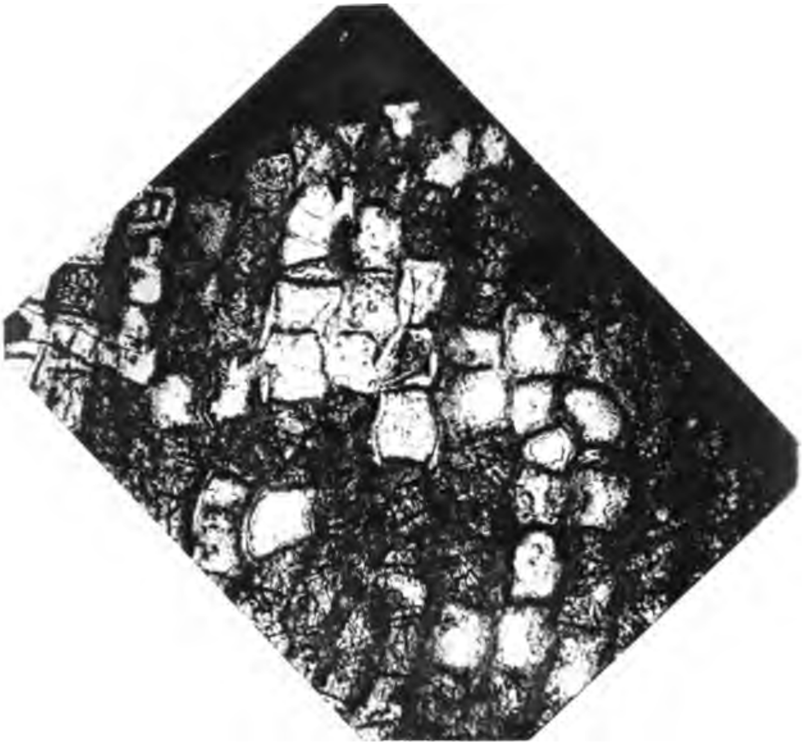

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PLATE XXVIII.

Syringopora auloporoides, *De Kon.*

Fig. 1. Horizontal section of four corallites, prepared for the micrpscope, showing tabulæ. x 12.

Fig. 2. More or less similar vertical section. x 12.

Woolomol.

1

2

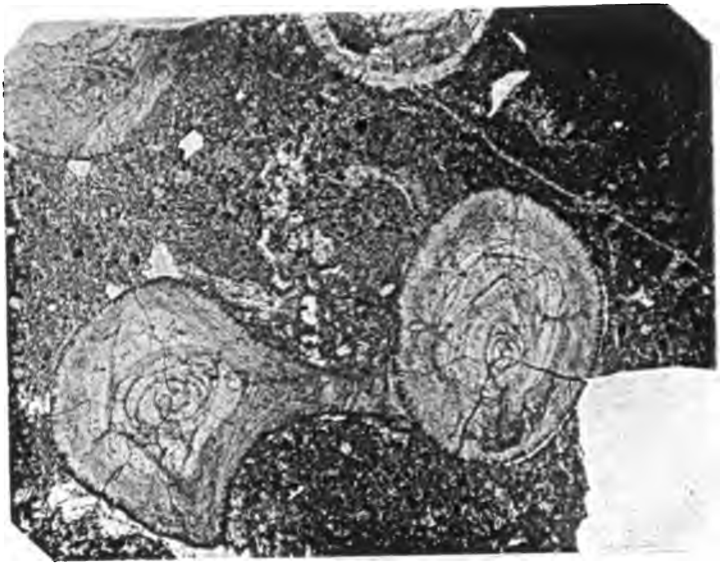
PLATE XXIX.

Syringopora novæ-cambrensis, *Eth. fil.*

Fig. 1. Horizontal section of four corallites, more or less prepared for the microscope, showing the cut edges of tabulæ, and a connecting process. x 12; N. W. of Tamworth.

Favosites basaltica, *Goldf.*, var. moonbiensis, *Eth. fil.*

Fig. 2. Vertical section of several corallites, prepared for the microscope, showing close set tabulæ. x 12; Beedle's Freehold.



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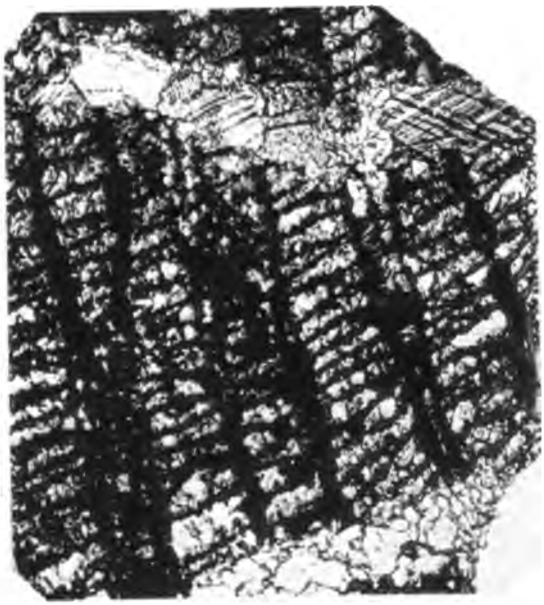

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PLATE XXX.

Microplasma parallelum, *Eth. fil.*

Fig. 1. Vertical section of a corallite, prepared for the microscope, showing the divided vesicular tissue. x 12.

Fig. 2. Similar horizontal section of corallites, showing the cut edges of the vesicles. x 12.

Moore Creek.

1

2

PLATE XXXI.

Syringopora Porteri, *Eth. fil.*

Fig. 1. Horizontal section, prepared for the microscope, showing the greatly thickened walls. x 12.

Fig. 2. Similar vertical section, showing thickened walls and septa. x 12.

Moore Creek.

1

2

PLATE XXXII.

Diphyphyllum robustum, *Eth. fil.*

Fig. 1. Horizontal section, prepared for the microscope. x 12.

Fig. 2. Similar vertical section. x 12.

Moore Creek.

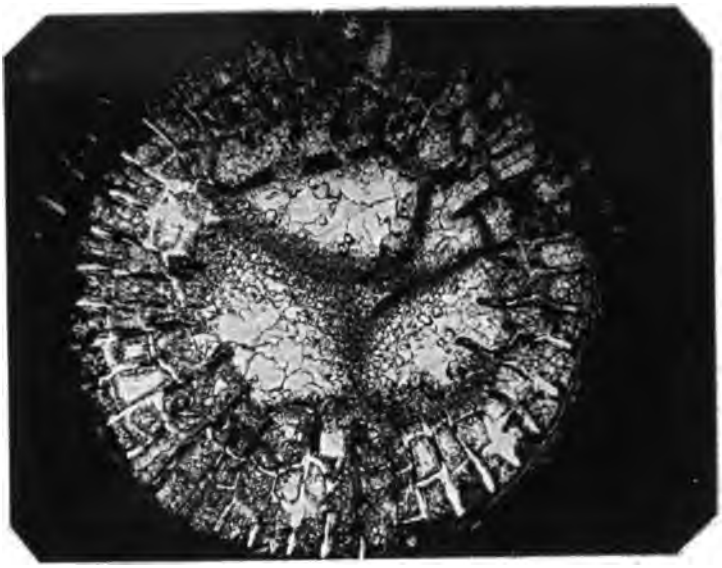

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PLATE XXXIII.

Syringopora novæ-cambrensis, *Eth. fil.*

Fig. 1. Vertical section, prepared for the microscope, showing portions of two corallites, with infundibuliform and oblique tabulæ. x 12.

Fig. 2. The same, and a few almost horizontal tabulæ. x 12.

N. W. of Tamworth.

1

2

PLATE XXXIV.

Favosites ? Pittmani, *Eth. fil.*

Fig. 1. Horizontal section, prepared for the microscope, exhibiting the highly thickened condition of the walls. x 12.

Fig. 2. Similar vertical section. x 12.

Beedle's Freehold.

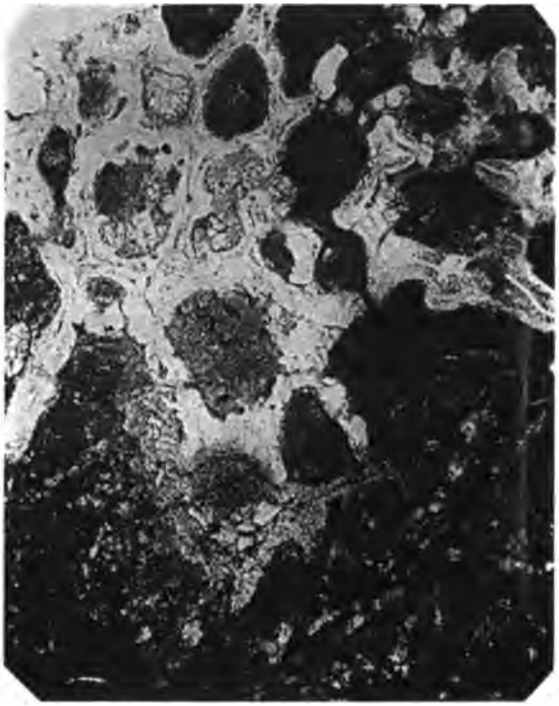

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PLATE XXXV.

Favosites ? Crummeri, *Eth. fil.*

Fig. 1. Horizontal section, prepared for the microscope, showing the thickened walls of the corallites and a few calices. x 12.

Fig. 2. Similar vertical section, too indifferent for description. x 12.

Moore Creek.

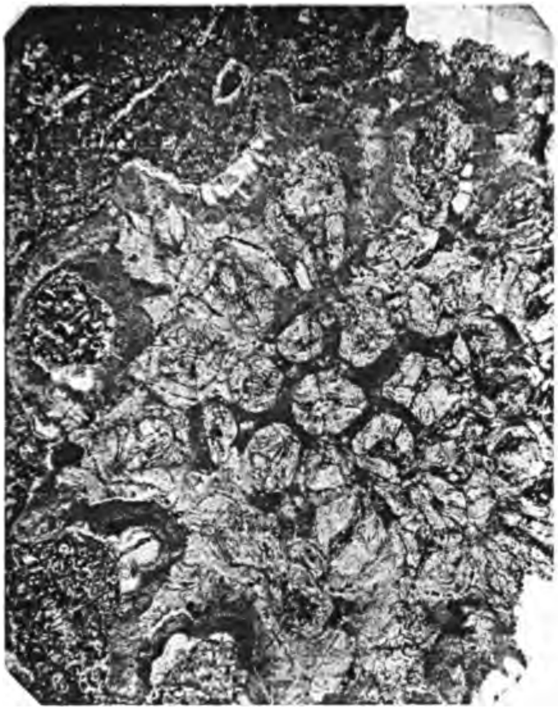

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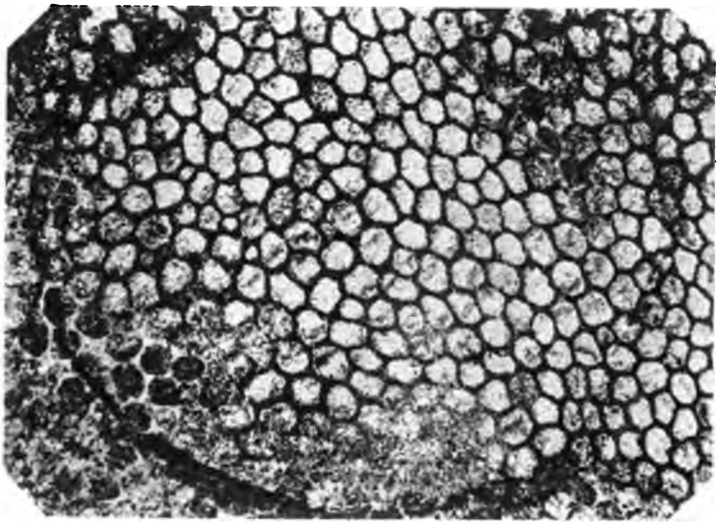
PLATE XXXVI.

Litophyllum Koninckii, *Eth. fil. and Foord.*

Fig. 1. Horizontal section, prepared for the microscope, showing the corallites and their non-septate character. x 12; Moore Creek.

Fig. 2. A similar section of a specimen with less polygonal corallites. x 12; Manilla Road.



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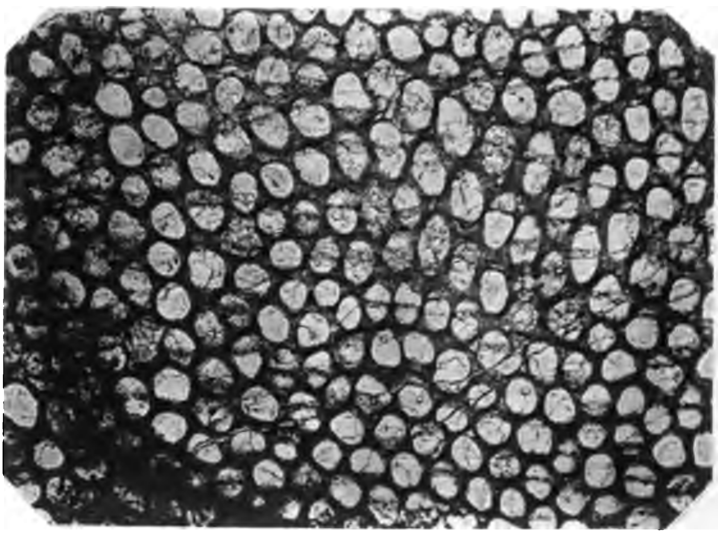

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PLATE XXXVII.

Litophyllum Koninckii, *Eth. fil. and Foord.*

Fig. 1. Vertical section, prepared for the microscope, showing tabulæ. x 12.; Manilla Road.

Diphyphyllum robustum, *Eth. fil.*

Fig. 2. Horizontal section, prepared for the microscope, too indifferent for description. x 12; Moore Creek.

1

2

PLATE XXXVIII.

Actinocystis cornu-bovis, *Eth. fil.*

Fig. 1. A somewhat imperfect corallum, side view, showing the weathered cysts or vesicles of the peripheral area ; Moore Creek.

Sanidophyllum Davidis, *Eth. fil.*

Fig. 2. Horizontal section of a corallite, prepared for the microscope. x 2 ; Moore Creek.

Spongophyllum giganteum, *Eth. fil.*

Fig. 3. Vertical section of a corallite, prepared for the microscope, showing the outer vesicular and septal areas. x 2 ; Moore Creek.

Favosites squamulifera, *Eth. fil.*

Fig. 4. Portion of a weathered corallum. x 2.

Fig. 5. Portions of four corallites, showing tabulæ, some complete, others incomplete and leaf or tongue-like, also mural pores. x 4.

"Tamworth," (? Woolomol.)

4

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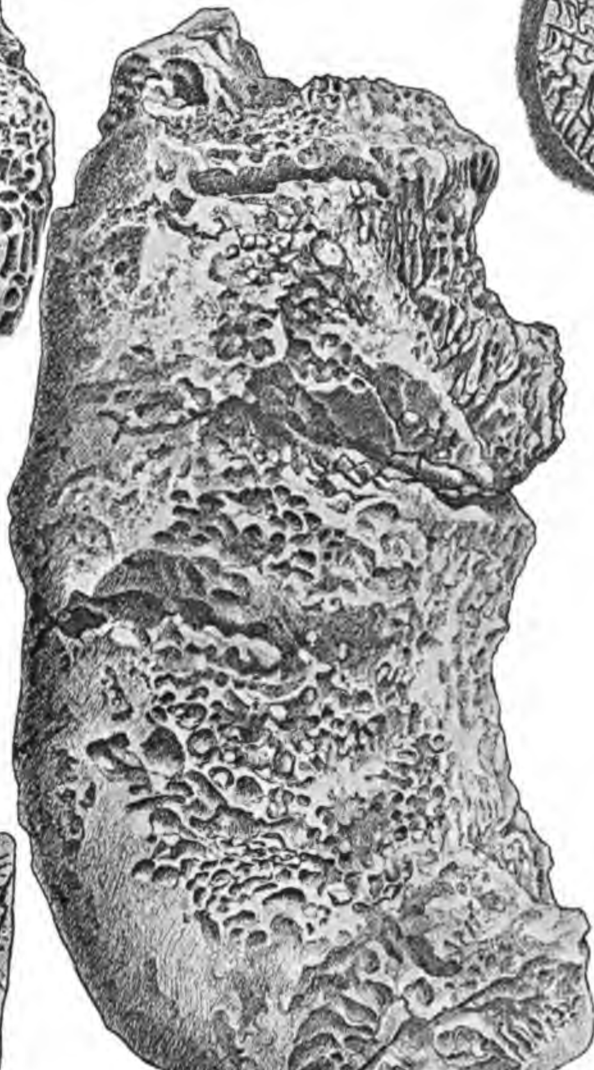

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Frank R. Leggatt, del.

CORRIGENDA.

Page 217, line 2, *for* Blaney *read* Blayney.

,,	218,	,, 6	,,	Jinberbyne	*read*	Jinderbyne.
,,	218,	,, 22	,,	Blaney	,,	Blayney.
,,	218,	,, 12	,,	Goodna	,,	Gooda.
,,	233,	,, 26	,,	Blaney	,,	Blayney.
,,	236,	,, 29	,,	Blaney	,,	Blayney.
,,	252,	,, 27	,,	Blaney	,,	Blayney.
,,	248,	,, 10	,,	Blaney	,,	Blayney.
,,	256,	,, 1	,,	Cummingar	,,	Cunningar.
,,	257,	,, 6	,,	Euabolong	,,	Euabalong.
,,	257,	,, 39	,,	Galley	,,	Gally, and add "or Gully"
,,	258,	,, 25	,,	Grey Mares	,,	Grey Mare's.
,,	262,	,, 15	,,	Moonbie	,,	Moonbi.
,,	260,	,, 18	,,	Kookabookra	*read*	Kookrabooka.
,,	264,	,, 7	,,	Nooroma	,,	Noorooma.
,,	275,	,, 23	,,	Emptive	,,	Eruptive.

,, 294, ,, 10 and 13, *for* Rheinschia *read* Reinschia.

,, 294, ,, 30 *for* 169 *read* 159.

,,	303,	,, 12	,,	Von	,,	von.
,,	304,	,, 20	,,	Blaney	*read*	Blayney.
,,	305,	,, 32	,,	Fatnash	,,	Falnash.
,,	308,	,, 19	,,	Subterannean	*read*	Subterranean.
,,	311,	,, 8	,,	Blaney	,,	Blayney.
,,	340,	,, 13	,,	Larry	,,	Larry's.
,,	340,	,, 21	,,	Alum	,,	Aluminium.

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DEPARTMENT OF MINES AND AGRICULTURE, SYDNEY.

RECORDS

OF THE

GEOLOGICAL SURVEY OF NEW SOUTH WALES.

Vol. VI.] June, 1900. [Part 4.

XV.—Contributions to a List of Papers and Reports dealing with the Economic Geology of New South Wales: by W. S. Dun, Palæontologist.

Contents. Page.

I.—Introduction.

The following bibliography aims at being a guide to the more important reports and papers dealing with the economic minerals, their associations, occurrences, and discovery as far as concerns New South Wales. Much of the literature of this subject is contained in the Annual Reports of the Department of Mines, New South Wales, in the form of Reports from the officers of the Geological Survey, Inspectors of Mines, Wardens, Warden's Clerks, and Mining Registrars. In the case of the last three classes of Reports, only those that have been thought to be more important have been selected.

Since 1891 the publishing in detail of the reports of the Wardens and Mining Registrars has been discontinued, and they are now abstracted and incorporated in the Annual Statements of the Under Secretary, which are to be found in the earlier parts of the respective volumes. These reports also contain statistical notes on the mineral production of the Colony.

Many reports on this subject, of prime interest, are to be found in the Votes and Proceedings of the Legislative Council of New South Wales for 1851–58, which contain reports by the Rev. W. B. Clarke, Stutchbury, and Hargraves, and the various Gold Commissioners. The majority of these were republished in England in the form of Parliamentary Papers—"Correspondence and Further Papers relating to the Recent Discovery of Gold in Australia," during the years 1852-56.

It has not been deemed expedient to publish references to the large number of assays and analyses that appear from year to year in the Annual Reports of the Department, as it has been thought that this course would swell the index greatly without giving any corresponding benefit. It has also not been considered feasible to include in this "List" references to articles, as a rule unsigned, appearing in local papers.

References to a few general works dealing to a greater or less extent with the Mineral Industry of the Colony have not in all cases been classed under each mineral heading, but from their titles they will appeal to all enquirers into the subject:—

(1.) CLARKE (W. B.) Remarks on the Sedimentary Formations of New South Wales, &c. (8vo. Sydney, 1867, 1871, 1875, and 1878.)

The first edition of this work was included in "The Catalogue of the Natural and Industrial Products of New South Wales" (pp. 65–80) prepared for the Paris Exhibition of 1867. It was also republished in the "Official Record of the International Exhibition of Australasia," Melbourne, 1867, and in the American Journal of Science, 1868, XLV (2), pp. 334–353. The second (1871) edition was included in the "Report of the Intercolonial Exhibition of 1870," held at Sydney, and also in "The Industrial Progress of New South Wales." The third (1875)

edition was printed in the "Mines and Mineral Statistics of New South Wales" prepared for the Philadelphia Exhibition. The fourth edition, greatly enlarged, was published at Sydney, as a separate work in 1878.

(2.) LIVERSIDGE (A.) The Minerals of New South Wales. (8vo. Sydney, 1888.) The first edition of this work appeared as a paper read before the Royal Society of N. S. Wales in 1874 (Trans. R. Soc. N. S. Wales for 1875 (1876), IX, pp. 153–215). The second edition was included in the 1882 edition of the "Mineral Products of New South Wales." Many other papers by Professor Liversidge dealing with the minerals of N. S. Wales from the scientific mineralogical, and not economic, side have been published in the Journal of the Royal Society of N. S. Wales; these, for the reasons above given, are not all quoted in the list.

(3.) The Mineral Products of New South Wales. (4to. Sydney, 1882.) This work includes:—

(*a.*) WOOD (H.) Mineral Products of New South Wales.

(*b.*) WILKINSON (C. S.) Notes on the Geology of New South Wales.

(*c.*) LIVERSIDGE (A.) Description of the Minerals of New South Wales.

(*d.*) ETHERIDGE (R., JUNR.) and JACK (R. L.) Catalogue of Works, Papers, Reports, and Maps on the Geology, Palæontology, Mineralogy, &c., &c., of the Australian Continent and Tasmania.

(4.) The Mineral Products of New South Wales. 2nd edition. (4to. Sydney, 1887.) Contains:—

(*a.*) WOOD (H.) Mineral Products of New South Wales.

(*b.*) WILKINSON (C. S.) Notes on the Geology of New South Wales.

(*c.*) MACKENZIE (J.) Description of the Seams of Coal Worked in New South Wales.

(5.) LYNE (C.) The Industries of New South Wales. (8vo. Sydney, 1882.) [Contains short accounts of Gold, Silver, Coal, Iron, Copper, Tin, and Shale Mining.]

(6.) The Industrial Progress of New South Wales: being a Report of the Intercolonial Exhibition of 1870, at Sydney; together with a variety of papers illustrative of the Industrial Resources of the Colony. (8vo. Sydney, 1871. By Authority.) Contains:—

(*a.*) CLARKE (W. B.) Remarks on the Sedimentary Formations of New South Wales, &c. 2nd edition, p. 505.

(*b.*) CLARKE (W. B.) On the Progress of Gold Discovery in Australasia, from 1860 to 1871, p. 533.

(*c.*) KEENE (W.) New South Wales Coal-fields, p. 557.

(*d.*) TAYLOR (N.) and THOMPSON (A. M.) On the Occurrence of the Diamond near Mudgee, p. 567.

(7.) NEW SOUTH WALES INTERCOLONIAL AND PHILADELPHIA INTERNATIONAL EXHIBITION. Mines and Mineral Statistics of New South Wales, and Notes on the Geological Collection of the Department of Mines, compiled by direction of the Hon. John Lucas, M.P., Minister for Mines. Also Remarks on the Sedimentary Formations of N. S. Wales, by the Rev. W. B. Clarke, M.A., F.G.S., F.R.G.S., Member of the Geological Societies of France and Austria; and Notes on the Iron and Coal Deposits, Wallerawang, and on the Diamond-fields, by Professor Liversidge, F.C.S., F.G.S., Sydney University. (8vo. Sydney, 1875.)

(8.) CARNE (J. E.) Notes on the Mineral Resources of New South Wales, as represented at the Melbourne Centennial International Exhibition of 1888. *Records Geol. Survey N. S. Wales*, 1889, I, Pt 2, pp. 33–114.

(9.) Short Notes on the Mineral Products of the Colony are included in the Catalogues of the Mineral Exhibits sent to various Exhibitions, Intercolonial and International—Paris, Amsterdam, Calcutta, London, Adelaide, Melbourne, New Zealand, Sydney International, and Chicago.

(10.) Information, mainly statistical, is also contained in the annual volumes, "Seven Colonies of Australasia," and "The Wealth and Progress of New South Wales" issued by the Government Statistician, Sydney.

(11.) General Statistical Information mainly taken from the Annual Reports from the Department are also annually published in statements of the Mineral Industry of the World issued by various Governments and Technical Journals.

As to the general arrangement, the classification is under the various metals. After "Gold" and "Coal" are placed locality indices to the papers quoted. A more complete bibliography of the already extensive literature relating to the Australian Permo-Carboniferous Coal Measures, in which full attention is being given to the scientific side of the question—correlation, palæontology, &c., is now in course of preparation. It is intended that this will form an Appendix to Professor David's Memoir on the New South Wales Coal Measures, now in preparation.

It is hoped that no important reference to the economic side of the wide subject of the Mineral Industry has been lost sight of. Many trivial references have been omitted, and it is hoped that the result will prove of some value.

GOLD.

ADAMS (R.):—

1 Gold in New South Wales. *Mining Journal*, 1873, XLIII, p. 1150.

2 Gold Mining in New South Wales. *Ibid.*, 1874, XLIV, p. 833.

3 Gold Mining in New South Wales. *Ibid.*, 1879, XLIX, p. 268.

ALDCORN (J.):—

4 Warden's Report on the Southern Mining District—Braidwood, Araluen Little River, Major's Creek, Nowra, and Nerriga Divisions. [Yalwal.] *Ann. Rept. Dept. Mines N. S. Wales for* 1888 [1889], pp. 82–83.

5 *Ditto.* [Yalwal.] *Ibid. for* 1889 [1890], pp. 79–80.

6 *Ditto.* [Jembaicumbene.] *Ibid. for* 1881 [1882], pp. 57-58.

7 *Ditto.* [Yalwal.] *Ibid. for* 1888 [1889], pp. 82–83.

ANDERSON (W.):—

8 Report on the Kiandra Gold-field. *Ann. Rept. Dept. Mines N. S. Wales for* 1886 [1887], pp. 165-166.

9 Report on the Country around Bingera. *Ibid. for* 1887 [1888], pp 156–159, map.

10 Report upon the Geology of the Districts around Coolabah and Byerock. *Ibid. for* 1887 [1888], pp. 161-163.

11 Report upon the Country between Nyngan, Nymagee, Cobar, and Girilambone. *Ibid. for* 1887 [1888], pp. 163–164.

12 The Geology of the Bingera and Barraba Gold-field. *Ibid. for* 1888 [1889], pp. 179–182.

13 Report on the Country immediately to the north of Molong. [Delaney's Dyke, Weandre Creek, Spring Creek.] *Ibid. for* 1888 [1889] pp. 183–184.

14 Report on Peak Hill. *Ibid. for* 1890 [1891], pp. 261-263.

15 Report on the Pambula Gold-field. *Ibid. for* 1890 [1891], pp. 263-264

16 Report on Mount Dromedary. *Ibid. for* 1890 [1891], pp. 264–265.

17 Report on the Cargo District. *Ibid. for* 1890 [1891], pp. 267-269.

18 Sketch Map, showing Geological Features between Peak Hill and Tomingley. 1890,

19 Notes on the Tertiary Deep Lead at Tumbarumba. *Records Geol. Survey N. S. Wales*, 1890, II, Pt. 1, pp. 21–26.

ANDERSON (W)—*continued.*

20 Geological Sketch Map of Tertiary Deep Lead, Tumbarumba. 1890.

21 Report on the Bendithera Silver-field and Currowan and Brimbermala Gold-field. *Ann. Rept. Dept. Mines N. S. Wales for* 1891 [1892]. pp. 252–254.

22 Progress Report on the Geology of the Major's Creek Gold-field. *Ibid. for* 1892 [1893], pp. 121–125, map.

23 Geological Map of part of the Elrington (Major's Creek) Gold-field, *Ibid. for* 1892.

ANGAS (G. F.) :—

24 Views of the Gold Regions of Australia. Pp. 2, 6 plates. (Folio. London, 1851.)

ANON :—

25 Mr. Hargraves on Australian Geology. *Mining Journal*, 1854, XXIII, p. 635.

ARMOUR (A. W.) :—

26 Mining Registrar's Report on the Tumut and Adelong District—Gundagai Division. [Muttama, Gundagai, Jones Creek.] *Ann. Rept. Dept. Mines N. S. Wales for* 1877 [1878], pp. 131–132.

27 Mining Registrar's Report on the Tumut and Adelong District—Muttama Division. *Ibid. for* 1882 [1883], pp. 74–75.

28 *Ditto. Ibid. for* 1883 [1884], pp. 86–87.

ARROWSMITH (J.) :—

29 Map of the South-eastern Portion of Australia, compiled from the Colonial Surveys and from details furnished by Exploratory Expeditions. [Showing gold localities.] *Gt. Britain, Parl. Papers —Further papers rel. Recent Discov. Gold in Austr.*, June 14, 1852, to face p. 26. *Ibid.*, Feb. 28, 1853, to face p. 1.

A. (S.) :—

30 Veber die Bildung des Moosgoldes und der grossen Goldnuggets. *Zeits. Prakt. Geol.*, 1894, Heft. 10, pp. 401–402. [*Vide* Nos. 445, 447.]

ATHERTON (T.) :—

31 Occurrence of a Native Sulphide of Gold. *Eng. and Mining Journ.*, 1891, LII, No. 25, p. 698; *Austr. Mining Standard*, 1891, VI, No. 154, p. 11.

BADCOCK (W.) :—

32 Mining Registrar's Report on the Bathurst District—Carcoar Division. [Mandurama, Junction Reefs, Flyer's Creek.] *Ann. Rept. Dept. Mines N. S. Wales for* 1876 [1877], pp. 76–77.

BAILEY (W. D.) :—

33 Mining Registrar's Report on the Tumut and Adelong District—Kiandra Division. *Ibid. for* 1882 [1883], pp. 71–72.

34 *Ditto. Ibid. for* 1883 [1884], p. 84.

BAKER (J.) :—

35 Warden's Report on the Hunter and Macleay District—Copeland Division. *Ibid. for* 1882 [1883], pp. 83–86.

36 *Ditto.* [Copeland.] *Ibid. for* 1880 [1881], pp. 174–180.

37 *Ditto.* [Copeland, Wangat.] *Ibid. for* 1881 [1882], pp. 87–93.

38 Warden's Report on the Lachlan District—Temora, Barmedman, Junee, and Cootamundra Division. *Ibid. for* 1883 [1884], pp. 65–68.

39 *Ditto.* [Wantiool.] *Ibid. for* 1885 [1886], pp. 63–65.

40 *Ditto.* [General Remarks on Mining Law.] *Ibid. for* 1891 [1892], pp. 85–87.

41 *Ditto. Ibid. for* 1890 [1891], pp. 76–78.

42 *Ditto.* [Muttama, Eurongilly, Mitta Mitta.] *Ibid. for* 1889 [1890] pp. 69–72.

43 *Ditto. Ibid. for* 1883 [1884], pp. 66–69.

44 *Ditto. Ibid. for* 1884 [1885], pp. 69–73.

45 *Ditto. Ibid. for* 1886 [1887], pp. 64–67.

BASSMANN (H.) :—

46 Mining Registrar's Report on the New England and Clarence District—Ballina Division. [Richmond R. Heads.] *Ibid. for* 1880 [1881], p. 171.

BARTON (H. N.) :—

47 Mining Registrar's Report on the Southern District—Moruya Division. [Mogo.] *Ibid. for* 1886 [1887], p. 74.

BECKE (E. H.) :—

48 Report on a Prospecting Tour on the Upper Hastings and Ellenborough Country. [Tobin's Creek, Tia, Ellenborough.] *Ibid. for* 1880 [1881], pp. 154–155.

BERRY (J. A.):—

49 Mining Registrar's Report on the Southern District—Nerrigundah Division. *Ibid. for* 1880 [1881], p. 129.

BIRKMYRE (W.):—

50 On the Effects of the Recent Gold Discoveries. *Mining Journal*, 1861, XXX, p. 207.

51 A Tabular Record, shewing generally the date of Discovery in Victoria and other Countries of the most Remarkable Specimens of Native Gold. (8vo. Melbourne, 1861.)

BLAKE (W. P.):—

52 The Production of the Precious Metals: or Statistical Notices of the Principal Gold and Silver Producing Regions of the World; with a Chapter upon the Unification of Gold and Silver Coinage. Pp. VII, 369. (8vo. New York, 1869.) [Australian Gold-fields, pp. 75–89, 308–315.]

BLIGH (R.):—

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Abbreviations :—The date implies the Annual Report of the Department of Mines for that year; M.P.: Mineral Products, 1887 Edition.

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